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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

NEW ENGLAND WATER WORKS ASSOCIATION

During the absence on military service of Major Richard K. Hale, the duties of the editor will be performed by Mr. Edward C. Sherman, of Rourke & Sherman, Consulting Engineers, 6 Beacon St., Boston.

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New England Water Works Association.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

WATER SUPPLY SANITATION IN THE NINETEENTH CENTURY AND IN THE TWENTIETH.

BY WILLIAM T. SEDGWICK, PH.D., SC.D., PROFESSOR OF BIOLOGY AND PUBLIC HEALTH, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON.

[*Read November 10, 1915.*]

Fellow-Members of the New England Water Works Association, — It is always a pleasure to come back to this room and to meet this company. It is also a great personal pleasure to reflect that I was at one time for one year your president, thanks to your kindness, and that I am one of your honorary members.

Fifteen years ago, or very nearly so, I read before the Association a paper on the "Rise and Progress of Water Supply Sanitation in the Nineteenth Century."* The reason for that was that we were then just ending the nineteenth century and people all over the world were bringing together the results of what was well called "The Wonderful Century." They were telling of the progress that had been made in art and in various sciences and in politics, in government, and all sorts of things, and it seemed to me right and proper that this Association, representing a great art and a great science in New England, and well known all over the world, should likewise stop and see what had been done during the nineteenth century for water supply sanitation. I prepared the paper with a good deal of care, and on looking it over lately, as I had not done for the nearly fifteen years that have gone by, I

* JOURNAL N. E. W. W. A.

am very much pleased, and not a little surprised, to find that what I said at that time I still believe to be entirely true. I have not found any statements that need to be made over.

The upshot of that paper was that in the nineteenth century it was discovered for the first time in the history of man that drinking water may convey disease. Up to the nineteenth century, people had supposed, many of them, that disease came as an act of divine Providence, or that it came as a punishment for sin, or that it came from meteoric disturbances, or from earthquakes or other strange things, and it was not until the middle of the century that we even discovered clearly that water could carry lead poison. That was the first discovery. And then we discovered that it could carry the germs of infectious disease. A great epidemic of Asiatic cholera in London, known as that of the Broad Street Well, happened in 1854. I was born in 1855, as I may mention in order that you may see that my life covers practically the whole period of our knowledge of water supply sanitation. It really covers a good deal more than that because we didn't get much sanitation until long after this memorable epidemic. In that famous outbreak six hundred people died — died, mind you, not sickened, from drinking the water of one well. And of course that fact taught a lesson to the world which it has never since forgotten. The details of that epidemic and other epidemics are given in the paper to which I have already referred and which I do not propose now to more than mention. That was in 1854. But although anybody looking over the evidence now is convinced immediately that it was the water of the well that did the work, medical men at the time — and they were the only men who seemed much interested — for the most part disbelieved the water theory; and although this was as plain a case as any one could wish, the best heads in London among the medical men, with one exception, came to the conclusion that after all the evidence was unsatisfactory and conflicting, and that it was not at all clear that the well had caused this fearful epidemic. Some said it was due to the fact that a number of years before a lot of dead bodies from Asiatic cholera victims had been buried in a field not very far off. Others came forward, no doubt, with the usual explanation of some meteor, comet, or earthquake, and most of them probably thought it an

"inevitable infliction of divine Providence." Dr. John Snow, however, a thoroughly scientific medical man, and Mr. Whitehead, a surveyor, worked the thing up very clearly, and any man who approaches the matter to-day unprejudiced cannot help being convinced immediately by all their data.

Now that was in 1854 and 1855. In 1866 there was another big epidemic of cholera traced to one of the London water supplies. In 1872 there was an epidemic of typhoid fever in Switzerland which set back all our sanitation in the nineteenth century, because the pollution in that case came through a hill to some springs in a little town named Lausen, and it seemed to people inconceivable that any infection could have been carried through a complete hill, a long hill. We now believe that there must have been a fissure or a channel through there; in fact, there was evidence at the time that there was. But people were more impressed by the evidence against that cause of the epidemic than they were by the evidence in favor of it. I remember that my distinguished predecessor and friend, William Ripley Nichols, for example, was always very skeptical about that particular epidemic. He didn't know anything about epidemiology — nobody did in those days, or hardly anything — and he had a right to be critical, particularly as his example in all these matters was important. Professor Pettenkofer of Munich was particularly cynical, critical, and sarcastic about it. Nevertheless, the truth undoubtedly was that typhoid fever germs had come through the hill, and to-day nobody disbelieves it who reads the evidence. That was in 1872.

In 1879, by which time I was just graduating from a scientific school, there was a typhoid epidemic traced to the pollution of a well which was being dug to add water to a small supply of a suburb of London, and the case there was so clear — when it was found that one of the workmen who had been digging in the well evidently had typhoid fever and had defecated in the well, so that the people had got his dejections pretty straight in the water — that the world began to see that water, after all, could carry the germs of disease.

In 1885 we had our greatest American lesson at Plymouth, Pa., when, out of 8 000 people, 1 200 came down with typhoid fever. That was not the worst epidemic of typhoid that we have ever

had, but it was the worst one that I know of due to water. Twelve hundred came down with typhoid out of a small population of 8 000. And it was absolutely proved in that case, to the satisfaction of everybody, that excreta from typhoid patients, thrown out on a little tributary of some small reservoirs supplying a part of the town, had been responsible for the epidemic.

Then came the Lowell and Lawrence epidemic of 1890, which many of those present will remember very well and which I personally had the opportunity to investigate. And after that there was no longer any doubt — and really even before this — that water could convey the germs of disease. But to show you how long we were in reaching this conclusion, and how slow the development of water supply sanitation was, even in the latter part of the nineteenth century, we have only to refer to the fact that one of the most distinguished engineers of the time, Mr. Cheesebrough, after a careful consideration of the conditions of the Merrimack River, reported in 1872 to Lowell and Lawrence that the best thing they could do to get a pure supply was to stick a pipe right down into that polluted river and pump the water to the people without any hesitation; "for it is clear," he said in substance, "from the examination of chemists, that running water purifies itself, and even the nine miles above the Lawrence intake are sufficient to render the water pure and safe." He did the same thing for Chicago and the same for Pittsburg, recommending them likewise to take highly polluted supplies, trusting, as he had a right to do, to the teachings of the chemists that running water purifies itself. But by the end of the century — for in the meantime had come the great typhoid and cholera epidemics in Hamburg in and before 1892 — by the end of the century, when I prepared this paper, it had become perfectly clear that running water does not adequately purify itself; and I am rather proud of the paragraph in my paper in which an idea is contained which had never been stated in quite the same way before, — although it is now well understood. The paragraph is headed, "Quiet water, not running water, purifies itself." And I remember the almost horror-stricken faces of some members of the Association when I read this paragraph, fifteen years ago. I will read it:

"The reason for this practice, now so thoroughly discredited"—

That is, the practice I had referred to in the previous paragraph, of taking water, as it had been taken at Lowell and Lawrence and Chicago and Pittsburg and Burlington, Vt., and many other places, —

" The reason for this practice, now so thoroughly discredited, was, as is well known, an undue reliance upon the so-called ' self-purification of streams,' a process which, though often real, is often also incomplete and untrustworthy. The idea prevalent in the greater part of the century that ' running water purifies itself,' while true enough up to a certain point and especially true so far as purification by dilution and by the displacement of dissolved gases is concerned, has in the last years of the century been shown to be either erroneous or to have little or no meaning so far as the direct oxidation of organic matter or the destruction of many living microbes which may be present in suspension, are concerned. For these latter, on the contrary, it would probably be more correct to say that ' quiet water purifies itself,' " —

I now often use the term " standing " water, — " stagnant " water, — for to stagnate means to stand,

— " since in such water microbes tend eventually to disappear, either dying from old age or inanition or settling to the bottom and being there detained."

That paragraph created a good deal of surprise at the time and also when it was published in my book on " Sanitary Science and Public Health." But it is absolutely true. It was true then and it is even truer to-day. We know better why this is so to-day than we did then. After summarizing things very much as I have done just now, I went on to speak of the influence of bacteriology upon the theory of filtration. I gave the history of filtration and the influence of bacteriology upon it, and I referred at the very end to experimental studies on filtration:

" Its theory and practice have been carefully studied, — perhaps more carefully at the Lawrence Experiment Station of the Massachusetts State Board of Health than anywhere else, — and its applicability to various kinds of water under various conditions has received elaborate and extended investigation, especially at Louisville, Ky., and Cincinnati, Ohio, under the direction of Mr. George W. Fuller, and at Pittsburg, Pa., by Mr. Allen Hazen. Under the advice and direction of Mr. Hazen, the city

of Albany, N. Y., in 1899 constructed a municipal filter of the most modern type for the purification of the polluted Hudson River which, unfiltered, had long been at once the source of water supply in Albany and the cause of an excess of typhoid fever. This filter has already demonstrated its sanitary efficiency and will probably stand in the future as a representative example of the best practical achievement of the century in the purification of a polluted water supply by slow sand filtration."

Then came a paragraph about the purification of water supplies against pollution at the source. With the experience of that suburb of London (Caterham) to which I have referred above, and of Pennsylvania (Plymouth) and of the Lowell and Lawrence epidemic, it required no great perspicacity to see that protection at the source is important. I then summarized the whole matter for the nineteenth century in a final paragraph, part of which I will read:

"PRESENT STATE OF THE SUBJECT."

"The nineteenth century has thus witnessed the gradual rise of modern water-supply sanitation, and considerable progress in its various branches. It is now agreed on all sides that impure water may be not merely a predisposing cause," —

as was alleged by many people, especially in the days of the Broad Street well. The wiseacre doctors said, "Well, possibly that well was a predisposing cause, but to think that it was the real cause is impossible,"

— "but the actual vehicle, of infectious diseases such as Asiatic cholera and typhoid fever. The 'ground-water' theory and the 'pathogenic' theory of typhoid fever have disappeared and the 'germ' theory is the only one recognized to-day."

That ground-water theory had a long and wide acceptance under the influence of Pettenkofer; and my friend Professor Nichols always shook his head when we mentioned the drinking-water theory of typhoid fever. One theory was known in Germany as the *Grundwasser Theorie* and the other as the *Drinkwasser Theorie.* Pettenkofer was in favor of the ground-water theory and Koch and his school were in favor of the drink-water theory.

"Filtration through sand, proposed in 1828, begun in London in 1829, and required by law for river-waters in London after 1855,

was at first slowly and empirically improved as an art, though its existence and sanitary value were repeatedly justified, especially in the cholera epidemic of 1866. It nevertheless passed under a cloud for a time, chiefly because of the phenomena of the Lausen epidemic of 1872, which seemed to show that even the most extensive filtration of an infected water supply was insufficient to remove the poison of the disease; and was only restored to its proper place in the confidence of experts after the lapse of time, the gradual accumulation of evidence in its favor, the powerful support of bacteriology, and especially after fresh and indubitable demonstrations of its efficiency and value, such as those afforded by the long experience of London, that of Altona in 1892 " —

a suburb of Hamburg which did not get cholera, while Hamburg did, although the Altona raw water was worse, Altona having filters and Hamburg not having them, —

— " and that of Lawrence in 1893, etc.

" The nineteenth century has also witnessed great progress in the general recognition of the absolute necessity of carefully protected watersheds, not only for the collection of surface waters which are to be used without filtration, but also for those — such as the water of the Thames — which are to be both settled and filtered before their consumption. It has learned to recognize the fact that the so-called purification of polluted waters by ' running ' in rivers, and even by ' storage ' in small reservoirs, is often incomplete and untrustworthy, and recognition of this fact has led to great and enormously expensive undertakings such as the Metropolitan Water Works of Massachusetts and the Sanitary Drainage Canal of Chicago, both designed to secure not merely more abundant, but also purer, water supplies."

That, then, was the state of affairs at the end of the nineteenth century, or substantially that. Some of those present will perhaps say that too much emphasis was laid in that last paragraph upon the importance of protection at the source, of the sanitary control of watersheds and the like, and there is possibly something to be said on that head.

Now, what are the broader features of water-supply sanitation in the first decade and a half of the twentieth century?

In the first place, I think we may say that there has been no abatement in our requirements for sanitation. Disease-producing,

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pathogenic, or infected water is even less tolerable to-day than it was then. These requirements — that is, the requirements for water-supply sanitation — were really mapped out and completed by the end of the nineteenth century, but our sanitary standards of to-day are higher than ever before.

In the second place, we have also raised our standards of prevention of infection. We consider prevention, sanitary collection, watershed purchase and control, and sanitary policing, of fundamental importance. But we have also learned that with the increase of population, especially suburban population, watershed ownership and control are becoming, and are likely to become, increasingly difficult.

In the third place, our faith in the great natural as opposed to artificial agencies of purification, filtration and storage, remains not only unabated but has been strengthened during the fifteen years under consideration. We believe to-day, even more than we did then, that quiet water rather than running water purifies itself, and great cities are depending on great storage basins for purification of their supplies, — and rightly so.

The Lawrence filter, the first in America to stand between a water both highly polluted and highly infected and a large industrial population, has now done its work faithfully for twenty-two years, and it has been successfully imitated by a host of followers. Storage, also, in the Wachusett Reservoir for the Metropolitan District of Massachusetts, and for many other great populations elsewhere, has abundantly proved its potency for sanitation.

On the other hand, we have not merely held fast to that which is good, but have also made brilliant advances. Progress, however, has taken the form not so much of prevention of pollution and infection as of cure by chemical treatment, of which chemical disinfection or sterilization by bleaching powder or liquid chlorine is undoubtedly the most important. Upon this I do not need to dwell. Supplies which are hardly deemed worthy of expensive filtration have been made safe by chemical disinfection. And we must understand that this is often differential chemical disinfection. That is to say, a disinfectant may be used of such a strength as to destroy germs present in the water, but not of a strength sufficient to destroy the people using the water. There is

differential treatment here just as there is in the administration of quinine for malaria. Quinine in sufficiently big doses is undoubtedly a poison, but quinine administered medically against malaria is what is called in medicine a specific, while in another sense it is a differential disinfectant.

Our other improvements have to do rather with the *refining* than with the sanitation of water supplies, and I may enumerate them as follows:

TWENTIETH CENTURY WATER-REFINING.

(*a*) *Final Sanitation*, by differential disinfection, etc.
(*b*) *Clarification*, by coagulation and sedimentation.
(*c*) *Differential Toxination*, by copper sulphate.
(*d*) *Decolorization*, by light and by coagulants.
(*e*) *Deodorization*, by aëration, etc.
(*f*) *Softening*.
(*g*) *Deferrization*.

I think we may see, in looking over the whole field and in comparing the twentieth century with the nineteenth, that our work in the twentieth century thus far has been largely, though not wholly, the *refining* of water. It is, of course, true that we have secured a very important new weapon in chemical disinfection, — an important sanitary weapon; but it is no less true that we have got a lot of improvements in the character of our waters which may well be called water refining, and which are of value quite apart from disinfection purposes or sanitary purposes, and these are, first, as stated above, *Clarification* by chemical coagulation, — that is to say, by the removal of turbidity and the carrying down of mud and the freeing of water from disagreeable appearance. Any one who remembers how the water was in Washington before it was filtered and as it is now after coagulation, or who remembers how it was in St. Louis before filters and coagulants were applied, knows very well what I mean.

Again, we have what I am calling *differential toxination*. I might call it intoxication or poisoning, but it is preferable to use some term that the public won't misunderstand, or won't understand at all, perhaps, and so I propose the term "differential toxination." It is the same idea, of course, as in chemical steri-

lization. By copper sulphate it is possible, as you know, to control troublesome algal growths by a process of chemical treatment which is practically intoxication and which is so arranged, so graduated, as to be differential. It will kill the growths but it won't injure the people who drink the water.

The next item which has come into great prominence in these fifteen years is *decolorization*. I very much wish, as I have often said to him, that Mr. Coggeshall would bring here and keep for us as a kind of perpetual show some of the old New Bedford water supply, which was as dark in color as dark tea. People were fairly content at one time with water as highly colored as that was and for most of the nineteenth century, but to-day decolorization has a distinct cash value with the public. And this whole matter of water supply treatment is becoming a refinement similar to that which leads us to prefer granulated sugar to the good old brown sugar with the molasses in it, which we had when we were youngsters, and which we still get sometimes, and which is very good, just as that old New Bedford water was most excellent though unattractive to look at.

Then, too, *deodorization* has come to have its value. There was a time — and it was not so far back in the nineteenth century, either — when water-works men did not take particular pains to deodorize water. They said, "The water is harmless and if you don't like the taste you must grin and bear it, or wait until the bad taste has passed by." But to-day tastes and odors — for most tastes are odors — are deemed well worth the closest attention of water-works officials.

Softening, too, has come in, beginning at Oberlin and Winnipeg, and a few other places, and has become one of the great things of the times; while one of the latest, as you know, is the treatment for iron, to get rid of excessive iron, *de-ferrization*.

Now, along with these, which I feel justified in calling refinements or processes of water refining, rather than processes of sanitation, we have had many interesting experiences. One of the most remarkable, I think, when the history of the time comes to be written, will be found to be that regarding the use of alum. In many cities there was no objection to the use of alum as a coagulant, but in some places there was very serious objection, — one

of the worst, probably, being Washington, or the District of Columbia, where the medical profession arose almost as one man and announced that it would not have alum used for the purification of the Washington water supply. The newspapers said that the people did not want "puckered" water; they didn't want "puckered" stomachs; and all sorts of devices were used to try to influence the people against the use of alum. They were assured that there was next to none in the water, but it didn't make any difference. And even intelligent medical men rose up and made a terrible powwow about the whole affair in medical meetings and delayed the proper purification of the Washington water supply for a number of years. Their attitude was very much like that of Liebig with reference to the microscope. Liebig, one of the most distinguished chemists of the nineteenth century, refused to look through a microscope, refused to believe that yeast was a living thing, refused to believe that you could learn anything by the use of a microscope, cast ridicule upon young men trying to follow in the footsteps of Helmholtz and Pasteur, and by his influence delayed the development of the germ theory for many years. A similarly unfortunate attitude was assumed by the medical profession in New York City at one time in respect to pasteurized milk. The behavior of the Washington medical men was much the same, and to-day, in the light of our experience with the use of alum all over the world, it is hard to see how intelligent men could have been so blind. It is a fact, however, and an interesting fact, in the history of our subject.

We are now catering in water supply to taste and comfort almost as much as to health. We are advancing from water supply as an art to water supply as a science. And here as everywhere we are assisting nature. Sand filtration and storage we must still employ, but these are not always sufficient. Nature often breaks down under unnatural conditions. Art and science must come to her aid. That they are doing so already in water supply science is obvious to any one who reads the signs of the times.

In connection with this fact, — that we are now entering upon a period of water refining, — it ought also to be said that the American public appear ready and glad to pay for such refining.

But it is a curious and interesting fact that they are as yet unwilling to do the same thing for the refining of milk. A little increase in the water rates for the benefit of an improved water supply, even in respect to its refinement, is, as a rule, cheerfully borne by a community, but any increase, however small, in the price of milk, which shall make it cleaner and safer and more abundant, has generally met with bitter opposition on the part of the consumer and almost everybody else except the producer. The human animal is a strange beast. It seems sometimes as if he was intelligent only in spots, — just as he is clean only in spots and moral only in spots. I congratulate this Association that in respect to water, at any rate, he does appear to be ready to meet the necessities of the case and to pay more for refined water than for unrefined, just as he cheerfully pays more for refined than for unrefined sugar.

SOME WATER-WORKS EXPERIENCES IN HARTFORD, CONN.

BY CALEB MILLS SAVILLE, CHIEF ENGINEER, HARTFORD WATER WORKS, HARTFORD, CONN.

[*Read December 8, 1915.*]

INADEQUACY OF SUPPLY.

The inadequacy of the present works supplying water to the city of Hartford was recognized considerably over a decade ago, but, due to different causes and combinations, the project did not take definite shape until the latter part of the year 1911. After this, owing to legal and land questions, the first contracts for an additional supply could not be let until nearly a year later.

The present source is a series of six reservoirs for storing surface water gathered from the easterly slope of Talcott Mountain, and is located about six miles west of Hartford City Hall. In extremely dry years this source is estimated to be able safely to yield about 7.5. m.g.d. Although in average years a yield in the neighborhood of 9.5 m.g.d. can be counted on, it has, however, been very disquieting, to say the least, when the reservoirs have been depleted to such an extent that only a few hundred thousand gallons remained in storage. This has happened twice within the past five years, and in one year during this period the reservoirs failed to fill. Due to the metering of nearly every connection in the city, the consumption of water in Hartford has been kept at a rate of about 66 gal. per capita. The population of the city, however, has increased rapidly, and the increase in the amount of water used has been within proper limits. In 1905 the consumption was 6.8 m.g.d.; in 1910, 7.7 m.g.d., and for 1915 the amount will not be far from 9.4 m.g.d. Works for an additional supply are now in process of construction, and, with these completed, it is estimated that at least 30 m.g.d. will be added to the present supply in periods of greatest drought. This water, however, will not be fully available until early in 1918, but

the works have proceeded to such a point that in case of emergency some help can be obtained from them. Hartford, therefore, is now for the first time in many years beginning to be freed from the threat of taking emergency water from a polluted source, and the beginning of the end of water shortage for many years to come is now close at hand.

In the years 1908 to 1914, inclusive, all New England and neighboring territory passed through a period of extremely low rainfall, and Hartford also was very close to water famine during the entire time. What emergency measures were taken in the face of this danger will be briefly stated. The problem was not a new one in the history of the Hartford Water Board. To meet similar conditions in 1899–1900, two Worthington pumps with a nominal capacity of 5 m.g.d., together with necessary boilers and other appurtenances, were purchased and temporarily installed on the bank of the Connecticut River north of the stone bridge, at an approximate cost of $14 700. Soon after this, however, rain fell in abundance and it was not found necessary to use the plant.

In the report for the year 1908, it is stated that, "owing to the peculiar climatic conditions of the past season, the depletion of the reservoirs was very great and caused the members of the Water Board much anxiety." When the water in the reservoirs reached a point where there was barely enough to supply the city for three months, it was decided by the Board to lay a pipe line from the Farmington River to such a point that water could be pumped through it over Talcott Mountain and then flow by gravity into the Hartford Reservoir System. About $15 000 was spent for cast-iron pipe for this purpose, but the rains came on and the necessity at that time was averted. The next year, 1909, conditions of run-off did not greatly improve, and experiments were made to ascertain if a temporary supply could not be obtained in the vicinity of the Connecticut River, by means of driven wells. These experiments were unsuccessful, as the quantity was not sufficient to warrant the expense of a plant, and the water itself was so highly impregnated with iron as to be practically worthless for domestic purposes. Attention was again turned to the Connecticut River as a source of supply.

Mindful of an epidemic of typhoid fever that had appeared in the city the last time water from the Connecticut River was used, experiments were made for disinfection, using hypochlorite of lime. The results of these experiments seemed to justify the conclusion that an effluent free from typhoid germs could be produced by the use of 1.5 parts available chlorine per million parts of water. The reservoirs again filled, however, before it was necessary to use this water, and the emergency plant was not required. In 1910, a shortage of water being again feared, the Connecticut River pumps were once more given attention, and the entire plant put in condition for use at a cost of about $5 000. In 1911 the reservoirs failed to fill during the spring, and much anxiety was felt concerning the supply. Early in the fall, however, due to very heavy rains in October, the reservoirs were completely filled by the first of 1912. The first of June the water in the reservoirs began to drop, and there was a steady depletion of storage all through the summer and fall. Once again the river pumping plant was overhauled and made ready for use. The results of careful investigations and tests at this time plainly showed that the plant was in no condition to combat a serious shortage. Various means of meeting the emergency were considered, most of which included the use of river water to some degree. No one wanted to use this water, and it was desirable to keep it out of the pipe system, even if it were sterilized. As affording some slight relief, pressures throughout the city were reduced about 12 lb. by throttling gates on the main supply pipe lines, and it was estimated that this action resulted in a saving of about one third of a million gallons of water per day. Again, however, the rains came in time, the reservoirs filled, and the danger of shortage was over for a while. During the succeeding summer the reservoir storage fell at a rate which had become usual during the past five years. In November and December, due to heavy rain and mild weather, the storage started upward but the reservoirs did not become filled until the last of May, 1913. They then almost immediately started down again at the customary pace, until a very heavy October rain with succeeding lighter falls added nearly 700 million gallons in fourteen days, and the danger was past for that year. Starting with full reser-

voir storage of about 2.1 billion gallons, the last part of May, 1914, the reservoir storage began to drop so that early in August serious consideration was again given to the matter of an emergency supply. The supply line connecting the additional supply works with the present reservoir system had been completed, and the first thought was to augment the supply by drawing water from one of the feeders of the proposed reservoir. It was realized, however, that the flow of Phelps Brook could be relied upon to furnish only a comparatively limited amount of water should conditions become really serious. On this account it was decided, therefore, to use the brook water so far as available and also, in order to be prepared for ultimate necessity, to authorize the construction of works for obtaining water from the Farmington River. As had been the case two years previously, throttling of gates was again resorted to, with the result of a saving of about 300 000 gal. per day. This means of conserving water will be taken up in detail later.

Emergency Works, Farmington River.

The Connecticut River source had been mentioned but was not seriously considered on account of local sanitary conditions, the nominal inadequacy of the pumps to furnish a sufficient supply if the necessity for use actually came, and the practical certainty that the plant could not be relied upon for constant service if started. The Farmington River offered a source for auxiliary supply which, while known to be polluted and in other ways far from ideal, nevertheless offered advantages for an auxiliary and emergency supply that outranked other practicable sources. The advantages of this source were the following:

A pumping station could easily be constructed on the Farmington River banks near the new supply pipe line, and, through this and the new conduit, water could be delivered into the present reservoir system.

A high-voltage electrical line crossed the river at this same point, and power for operating the pumps was immediately available.

Regarding pollution, there was little choice under ordinary conditions between the Farmington and Connecticut rivers, but even what there was favored the former source.

Regarding the disinfection and sterilization of the effluent from the two sources, there was much in favor of the Farmington River supply. In the case of the Connecticut River, the only reliance was a hypochlorite plant forcing the chemical into the suction main of the pumps which discharged directly into the distribution system with little or no time for action. In the case of the Farmington River water, double hypochlorite treatment and sedimentation for some hours in the reservoir was possible before the water reached the city. Besides this, variations of wind, tide, and sewage discharge in the vicinity of the Connecticut River station brought about constantly changing conditions at the intake. In the case of the Farmington River station, pollution conditions were very uniform, and a long reach of slowly flowing water above the station was recognized as being of very great value from a sanitary standpoint. The total cost of the emergency plant constructed on the Farmington River was about $13 500, including land, pumping station, electrical and hydraulic machinery, and all incidentals and appurtenances required to deliver water into Reservoir No. 1.

As designed and built, the pumping station has a capacity of 4 m.g.d. Provision was made for the immediate addition of another pumping unit should it be required; the discharge main was of ample size for any ordinary expansion of the plant; and by comparatively inexpensive construction the intake could be extended if necessary. The discharge main from the pumps connects with the 42-in. main through the inspection manhole on top of a blow-off branch in that main. The cover of this manhole was unbolted and a specially cast flanged riser bolted on to the flange of the blow-off.

As stated above, the station is located on the banks of the Farmington River near the crossing of the Nepaug Pipe Line. This pipe line is of cast iron, 42 in. in diameter, and has been constructed recently to bring water from the new supply to the present reservoir system. Starting from the gate-house at the Phelps Brook dam, it extends about 7½ miles southeasterly to the westerly entrance of the concrete conduit, also newly built. By means of this conduit, a half-mile tunnel and an additional mile of conduit yet to be built, water will ultimately be delivered

into Reservoir No. 5 of the present system. From the open easterly end of the concrete conduit, by means of a short section of open ditch, water can be delivered into a brook which flows into Reservoir No. 1, the present distributing reservoir of the city works. Along the pipe line the location of the pumping station is about 3 000 ft. west of the entrance to the conduit, which is also the summit over which water was to be pumped. On account of local conditions, a centrifugal plant, electrically operated, seemed to offer the best solution of the pumping problem, and tenders for the construction and installation of this plant as a whole were invited from several large engineering and contracting companies. A comparison of the figures received and an estimate, based on the plant being furnished by the city and a contract for construction of station and installation of machinery, indicated that quite a substantial saving could be accomplished by the latter method. The final result showed that this decision was not a mistake. Besides the actual saving, the city was enabled to proceed step by step in the matter, watching the reservoir storage depletion and placing orders for plant only as seemed necessary to meet conditions. The pumps had to be made to order, and from four to six weeks were required for this purpose. The electrical machinery was standard and could be furnished in open market provided only that it was in stock. The following were the conditions of service proposed for the pumps:

Pumping capacity	1 400 g.p.m.
Static delivery head	178 ft.
Suction lift	20 ft.
Friction through 50 ft. of suction pipe, including elbows and foot valve	2 ft.
Total dynamic head	200 ft.

Current available, 11 000 volts, 3-phase, 60-cycle.

Proposals for furnishing the pumping machinery were received from five well-known and reputable concerns, the prices varying from $650 to $1 164. After careful consideration of the figures,

taking into account the time in which the pumps could be finished and the ability of the plant to meet the requirements without change or delay, the purchase was made from the Alberger Pump & Condenser Company, who guaranteed a pump efficiency of not less than 70 per cent. operating at full load speed of a 1 200 r.p.m. synchronous speed, 60-cycle induction motor transmitting 100 brake horse-power to the pump shaft. This concern also agreed to ship one unit within three weeks of the date of order and the second unit a week later. In order that there might be no delay in having the plant ready for service, a contract was also made with the pump company to furnish the motors, subject, however, to withdrawal of this portion of the order within two weeks if water conditions were such that work on the pumps could be suspended.

The pumps furnished were two 10-in. Alberger Type "v" turbine pumps, having cast-iron casings, bronze impellers, bronze diffusion vanes, and bronze-covered steel shaft where in contact with the water, mounted upon common extended cast-iron base plates and direct connected to the motors with flexible couplings.

The motors were two 100 h.p. General Electric, Form K, 1 200 r.p.m. synchronous speed, 2 200-volt, 3-phase, 60-cycle, squirrel-cage induction motors, complete, with hand-starting compensators and necessary potential transformers. Besides this the pump company furnished two Crane Fig. 547, 12-in. to 10-in. cast-iron reducers and two Crane Fig. 395, 12-in. combination foot valves and strainers.

For the erection of the temporary station and the installation of the machinery furnished by the Board, a contract was made with Fred T. Ley & Co., Inc., of Springfield, Mass.

The current available from the power line passing the pumping station was 11 000 volts, which it was necessary to step down for use with the motors installed. After consideration of cost and availability, should another pumping unit be required, it seemed desirable to install transformers with capacity sufficient to handle the power required for a third pump.

Ground was broken at the station on December 2, 1914, and the work proceeded rapidly until about January 1, when, on account of heavy rains and flood, temporary suspension was necessary.

These same rains and floods, however, caused considerable increase in the reservoir storage, and, while the danger of water famine was by no means past, the necessity of extreme haste was eliminated. A period of very cold weather now set in, which made outside work difficult and expensive. Under these conditions, as the work was being done on a cost basis, it seemed wise to suspend operations until a more convenient season.

By the middle of February, 1915, the construction and installation work being completed, the Alberger Company were notified that the pumps were ready for inspection by their erecting man, previous to running the acceptance test. The first test was made of both pumps February 21, and neither came up to the requirements of the guarantee, due to priming troubles, electrical starting apparatus, and a hot bearing on one pump. On March 12 a second test was run, and the north pump made a satisfactory showing, giving at 200-ft. dynamic head a discharge of 2.14 m.g.d., with an efficiency of 74.5 per cent.

A preliminary trial of the south pump indicated clearly that something was wrong. This pump was taken apart and a chip of wood 6 in. x $2\frac{1}{4}$ in. x $1\frac{1}{2}$ in. and a piece of coke about 6 in. long and about 1 in. square were found in the impeller. As this was thought by the pump engineer to have caused the trouble, no further search was made. On another test, however, the pump still failed to come up to the guarantee, although the performance was much more satisfactory. Again the pump was taken down and an aluminum bronze bushing was found either too tight in the shaft or else defective. A final and satisfactory test of this pump was made on March 29. At 200-ft. total head, the discharge was 2.03 m.g.d. with an efficiency of 72.6 per cent. (See Table 1.)

There seem to be at least two lessons to be drawn from these testing performances: First, acceptance tests should invariably be made in place and under as nearly as possible working conditions. Shop tests furnish interesting and valuable information but are made under such different conditions from those under which the pump is to work that the results can hardly be compared. Manufacturers' guarantees, no matter how reliable the firm or how honest the intent to meet requirements, should not be taken

TABLE 1.

TEST OF 10-IN. ALBERGER CENTRIFUGAL PUMP 7005, AT FARMINGTON RIVER STATION, ON MARCH 29, 1915.

(South pump in station.)

Test No.	Press. Lb. Sq. In.	Head. Ft.	Suction Hd.			Total Hd. in Ft.	Weir Measurements.			Speed. R.P.M.	Water. H.P.	Elect. H.P. Input.	Efficiency.		
			In. Mercury.	Ft.			Head on Weir. Ft.	Disch. Corr. for Leak.					Plant.	Motor.	Pump.
								Sec.-Ft.	M.G.D.						
1	77.5	179.	15.2	17.2	Press. gage 4.5' above vacuum gage.	200.7	0.448	3.17	2.05	1 183	72.1	108.9	66.3	91.3	72.6
2	30.5	70.5	18.2	20.6		95.6	.611	5.06	3.27	1 181	54.9	118.6	46.3	90.8	51.0
3	47.4	109.5	17.5	19.8		133.8	.580	4.69	3.03	1 180	71.2	121.3	58.6	90.5	64.8
4	61.4	141.8	16.5	18.7		165.0	.536	4.16	2.69	1 181	77.8	119.1	65.3	90.8	71.9
5	69.9	161.3	15.75	17.8		183.6	.493	3.65	2.36	1 180	76.0	114.1	66.6	91.0	73.2
6	78.4	181.	15.0	17.0		202.5	.436	3.05	1.97	1 185	70.0	106.3	65.9	91.3	72.1
7	85.8	198.0	14.4	16.3		218.8	.361	2.34	1.51	1 187	58.0	95.3	61.0	91.5	66.7
8	77.5	179.	15.1	17.2		200.7	.305	3.10	2.00	....	70.5	...	....	...	...

GENERAL NOTES. Weight of water per cu. ft., 62.4 lbs. Discharge measured by thin-edged weir without end contractions. Weir crest 3.0 ft. long and 2.0 ft. above bottom of flume. Discharge taken from Basin. Measured leakage from flume was 2.75 cu. ft. in one minute = 0.046 sec.-ft.

without verification. Second, no matter what the pump salesman asserts, centrifugal pumps for special service, or unless designed for the purpose, do not have the alleged digestive capacity of the ostrich. As for these particular pumps, the makers did everything

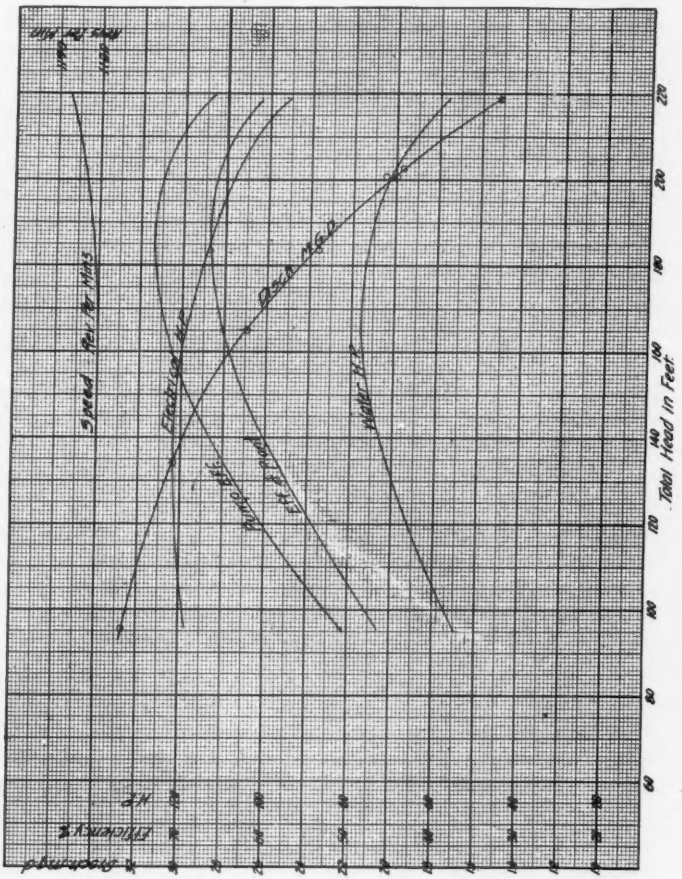

FIG. 1.

TEST OF CENTRIFUGAL PUMP, FARMINGTON RIVER STATION, MARCH 29, 1915.

in their power to live up to their guarantee, and after being whipped into shape these pumps are, I believe, most capable of satisfactorily fulfilling their purpose.

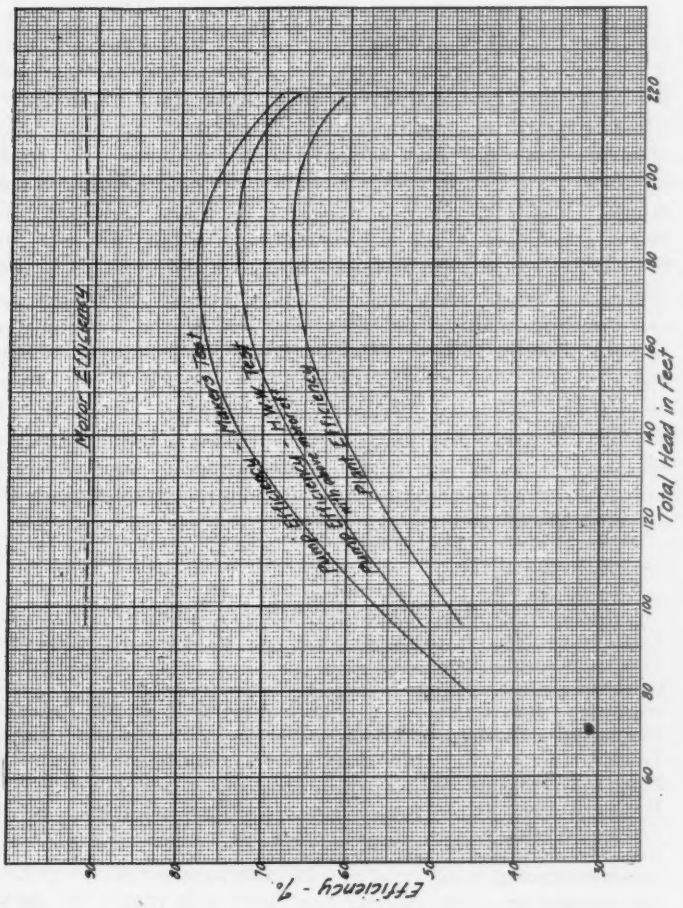

FIG. 2.

TEST OF CENTRIFUGAL PUMP, FARMINGTON RIVER STATION, MARCH 29, 1915.

The pumps were tested by discharging through the riser branch left in the discharge main for the third pump when installed. A 10-in. gate was strapped on to this branch, into which was leaded a quarter-turn facing southerly; a 10-in. by 16-in. reducer was put into this, and from here several lengths of 16-in. pipe were carried out through the building to a wooden flume. A quarter-turn on the end made the discharge take place at the bottom of the flume, and several baffle plates and a wooden partition bored full of holes destroyed all velocity of approach to a standard thin-edged weir without end contractions. The crest of this weir was 3 ft. long and placed 2 ft. above the bottom of the flume. Heights on the weir were read on a scale placed alongside a gage glass. This was connected to a pipe with several holes in it, that extended across the bottom of the flume. Varying heads for testing were obtained by throttling the 10-in. gate on the discharge main. The log of the test of the south pump is given above in Table 1. The diagram Fig. 1 shows graphically the relation of the test conditions, and the diagram Fig. 2 shows comparative efficiency relations. The efficiency given for the Hartford Water Works pump and plant tests is based on motor efficiency given by the makers. As the motors were standard apparatus, there seems little question but that this efficiency is substantially correct.

Cost.

Emergency Water Supply, Farmington River Station.

Land	$500.00
Temporary pumping station	6 060.91
Gatehouse screens	23.06
Pumps and motors	3 260.00
Foot valves, strainers, and reducers	120.00
Team hire	15.00
Pipe and fittings purchased	563.43
Pipe and fittings from stock	171.92
Transformers and switches	2 131.12
Inspection of pipe and fittings	3.40
Inspection of pumps	15.53
Bolts and gaskets	39.64
Valves	252.50
Rods for holding curves	29.35

Corrugated iron for fence	$23.40
Lumber for flume	29.01
Pipe fittings	2.55
Vacuum gage and repairing same	3.50
Barbed wire	2.04
Hose washers	.10
Leather packing	....
Turbine oil	3.25
Hand bellows	1.25
Speed counter	3.00
Hasp	.25
Electrical supplies	9.99
Repairing vacuum gage	1.50
Signboards	20.14
Lunches at pump tests	28.00
Payrolls — pump tests	123.50
Current for pump tests	41.80
Packing tools	2.25
Drills and tap	.75
Paint and brushes	11.70
Total	$13 493.84

Throttling Gates.

The water supply of the city is brought to the distribution system through three supply mains, one 30-in. line entering the southwest part through Park Street, and two 20-in. lines entering the central part through Farmington and Asylum avenues. Ordinarily the pressure at City Hall varies from a minimum of 58 to 60 lb. from 7 to 10 A.M., to a maximum of about 72 lb. between midnight and 4 A.M., the respective rates for draft at these periods being 14.65 and 4.8 m.g.d.

Because of the fact that the discharge of water is dependent on the head or pressure forcing it through an opening, it goes without saying that if the pressure is reduced the discharge also falls off. What the relation may be depends upon local conditions which are not material to this discussion. During the scarcity of water which has been mentioned above, many means for conserving the supply were tried, and among others the method of reducing pressure in the distribution mains by throttling of gates in the supply mains. This method was tried in Hartford two

years ago and resulted in a saving of about 300 000 gal. per day, estimated from the Venturi meter record at the effluent gatehouse. Because of the importance of this matter and its relation to fire protection, four old and reliable employees, whose regular work was the maintenance and repair of the gates, were assigned to this work, one of them being the foreman. Fire-engine houses conveniently located were chosen as stations for these men, and two were assigned to each of two houses, one located 1 600 ft. and the other 900 ft. from the operated gates. From 4 P.M. to 5 A.M. the endeavor was made to hold the pressure in the city a few pounds above that registered during the period of maximum draft and consequently least pressure. It was assumed that any industry having sufficient pressure during the forenoon would not be seriously inconvenienced if the same pressure were maintained at night. That this was correct was evident by the fact that no complaints of any kind were made by consumers.

By careful comparison, the difference in pressure at City Hall and at one of the engine houses (No. 12) was ascertained. A recording pressure gage was installed at the latter place and, by operating a 20-in. gate in Farmington Avenue, the pressure gage at the engine house was kept at such a point that the City Hall gage recorded a pressure a little higher than that shown during the period from 7 to 10 A.M. In order to accomplish this result, the foreman or helper stationed at Engine House No. 12 constantly watched the pressure gage after the main gate was closed until about midnight. During the evening, on account of gradually decreasing consumption, the pressure rises and the gate was throttled down little by little as was necessary to maintain the desired reading.

The operated gates have the following characteristics:

30-in. gate in Park Street requires 243 turns to open wide.
S20-in. gate in Farmington Avenue requires 52 turns to open wide.
N20-in. gate in Farmington Avenue requires 64 turns to open wide.

There is a 6-in. by-pass around the 30-in. gate. Under ordinary procedure the gates are operated as follows:

30-in. gate in Park Street closed completely at 4 P.M.
6-in. by-pass open all of the time.

N20-in. gate in Farmington Avenue closed 52 turns at 6.30 P.M.
S20-in. gate in Farmington Avenue closed 45 turns at 4 P.M.
47 turns at 5 P.M.
49 turns at 6 P.M.
Completely closed at 6.30 P.M.

And this pressure held constant by manipulation of this gate during the evening. At about midnight, on account of practically constant draft until 6 A.M., no additional attention was usually required. All three gates were opened at about 5.15 A.M. The four men assigned to this work from midnight to 5 A.M. slept at the engine houses under the same conditions as the firemen, with similar arrangements of clothing for quick dressing and getaway. Close check could be kept on the conduct of these men from inspection of the autographic chart records on gages located at City Hall and at Engine Houses 3, 12, and 15. From comparisons of official fire alarm time and the chart records, it was found that it took from one to two minutes for the men located at the stations to get to the gates, and from two to three minutes to get on full pressure. During the actual throttling period (about twelve hours) it appeared that the actual reduction in draft was at a rate of about 600 000 gal. per day. Of this it was estimated —and subsequent investigation confirmed the computation—that 3.75 m.g.d. passed through the 6-in. by-pass on Park Street and the remainder through the throttled 20-in. gate on Farmington Avenue. It thus appeared that the entire city was getting proper proportion of the supply and that a sudden draft in any section would be quickly met.

The insurance people are interested, and properly so, in the maintenance of an adequate supply for sprinkler systems. So far as pressure was concerned, that during the throttling period was from 4 to 6 lb. higher than that during the forenoon hours of each day.

Under conditions of piping approved by the Associated Factory Mutual Fire Insurance Companies, 50 sprinkler heads in the top of a four-story building are satisfactorily served when there is available an average discharge for each equivalent to about 12.9 gal. per minute when all are discharging at once. This condition will occur with a street pressure of about 55 lb. per square inch

and a pressure of 20 lb. per square inch at the top of the riser. Under this condition a floor space of about 100 ft. by 50 ft. would be covered with a total discharge of about 645 gal. per minute.

As a part of the fire protection system, all factories maintain watchmen, and the noise of running water even from one or two sprinkler heads should be quickly noticed and investigated. With any adequate system of patrol, long before any large number of sprinkler heads let go, an alarm would be rung in and the gates fully opened to provide for a large fire draft.

Before entering on this work several computations were made as to the effect of a sudden increase in consumption with the gates throttled, and it appeared that a sudden draft of 550 gal. per minute would cause a drop of from four to five pounds. The results so obtained were roughly checked by observation of not dissimilar conditions that obtained when a locomotive filled its tank at the railroad station. This latter matter has been brought before the Association* in reference to the water ram effect of these sudden large drafts on the pipe system. Since then, and in connection with the matter of gate throttling, additional observations were made with the following results:

Time.	Train No.	Standpipe.	Total Draft. Cu. Ft.	Length of Draft.	Rate of Draft.	
					c.f.p.m.	g.p.m.
9.10 P.M.	64	Church St.	506	2 min. 12 sec.	230	1 720
11.14 P.M.	Dinkey	Asylum St.	218	1 min. 15 sec.	175	1 305
11.33 P.M.	66	Church St.	491	2 min. 9 sec.	228	1 710

The first and last of these rates is over three times that of the sprinkler requirements stated above.

From study of the drops on the pressure charts due to these and other similar drafts, it appears likely that a sudden draft at a rate of 1 600 gal. per minute causes a drop of about 11 lb.; and one of 1 300 gal. per minute, a drop of about 9 lb. per square inch in the Hartford system.

On account of the importance of this matter, however, and in

* Journal N. E. W. W. A.

order to have independent confirmation, a test was run at the pipe yard after midnight, and unknown to the men on the gates. A discharge at a rate of 560 gal. per minute was run through a 4-in. Crest meter and maintained at this rate for about fifteen minutes. Pressures at the time of this test were observed on the gage located at City Hall. The resultant drop was about five lb. per square inch. This seemed to indicate clearly that if a large number of sprinkler heads let go at once the drop in pressure would not be much in excess of 5 lb. before a fire alarm could be turned in and the gates on the supply lines opened.

But possibly some one will say the tests show up well and probably would work out in practice, still it would be more satisfactory to have a practical demonstration. It was furnished under most adverse circumstances at a fire the morning of December 13, 1912, about 500 ft. from fire station. Fire was discovered in a hay and grain storehouse in one of the congested parts of the city. Two alarms, 10 pieces of apparatus, and 8 streams were required. The pressure chart shows that there was full pressure available in the mains when wanted. It is also shown that the pressure was reduced about 10 lb. at 3 P.M., gates opened at about 7.30 A.M. and 12.30 A.M. for previous alarms, and in each case closed down after the all-out signal. The fire was located not far from a gage station, and the pulsations of the streams are very plainly shown on the chart, as is also the withdrawal of several of them a little after 3 A.M.

Regarding the conservation of water from reduction of pressure, it is understood that this method has been in use on the Brooklyn, N. Y., supply for many years with no trouble. Also that as a result of an experiment in cutting down night pressure in Philadelphia, a saving of five million gallons per day was recorded without inconvenience to residents.

OLD CAST-IRON PIPE.

Ground was broken for the Hartford Water Works in 1854, some of the pipes laid in that year are in use, and about 15 miles of pipe laid between 1854 and 1861 are still in service.

OLD CAST-IRON PIPES IN SERVICE, 1915, HARTFORD WATER WORKS.

	LENGTH IN FEET.							
Year Laid.	3-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	Total.
1854			1 921	2 326		1 060		5 307
1855			3 071	1 945	2 525	2 361	6 864	16 766
1856	442	193	13 852	4 113	1 072			19 672
1857		1 220	13 479	6 238	457			21 394
1858		811	780					1 591
1859		3 351	4 882					8 233
1860			2 177					2 177
1861			3 438					3 438
Total	442	5 575	43 600	14 622	4 054	3 421	6 864	78 578

Wrought-iron, cement-coated mains came into vogue in 1863 on account of the comparatively low cost, and for a number of years no cast-iron pipe was laid in Hartford. Owing to its greater reliability, cast-iron gradually replaced the cement-lined pipe, and only a comparatively little of this latter pipe is now in use in the city. It is interesting to note that probably the most of the old cast-iron pipe is uncoated and was cast in a horizontal position instead of vertically as at present.

During the past year, new pipe has been laid in many streets formerly served by pipes laid many years ago. This action has been taken not because intrinsically the pipe had worn out or become useless, but solely because the community served is now a populous city district rather than a sparsely settled suburb. The iron in this old pipe was of excellent quality, and, except for the cost of salvage, it might well have been used elsewhere. The cost of removing these pipes, however, is usually found to exceed their value on account of other underground structures, street railway tracks, and improved street surfacing, to say nothing of the often very erratic alignment of the old layout. Some of the pipe is badly tuberculated and other partly filled with sediment, but if the pipe had not been too small for modern requirements in this district, it propably would have paid to clean it. So far as permanency goes, all of this pipe shows that cast iron is an ideal material for water pipes and that up to the present time no

other substance has been found from which generally such satisfactory results can be obtained. There are three principal features to be considered in selecting water pipes — permanency, carrying capacity, and cost. Fifty-five to sixty years' service, and a condition such that life ahead cannot be estimated, certainly meets the first requirement. Well-laid clean or cleaned cast-iron pipes have a carrying capacity not greatly inferior to that of any other materials that have been used, and, if capitalized cost based on longevity of service is taken as a criterion, it appears that all these requirements for water pipes have been met.

So far as possible, when these old pipes are replaced, an endeavor is made to get some idea of their condition and capacity. The condition is obtained from an inspection of sections cut from the main. The capacity is found by discharge tests. In these tests the quantity is obtained either by using a meter or by pitometer, pressure gages placed near the inlet and outlet ends of the pipe giving fair information regarding friction losses under varying conditions of flow.

Meters of standard makes are used on the tests, and these are tested before and after. The gages are 6-in. Crosby Standard Test Gages, graduated in pounds per square inch from 0 to 120 with corresponding heights of water in feet from 0 to 277. These gages are tested on an oil testing machine before and after using, in the position as used on the pipe test, and proper corrections made for error in registration due to this cause. Below are given summaries of the tests of several pipe lines which had been in actual use for a considerable period.

Street.	Size.	Length. Feet.	Age. Years.	Inspection Number.
1. Kennedy Street.....	4-in.	670	57	D-328
2. Wooster Street.....	4-in.	962	58	D-330
3. New Park Avenue.....	6-in.	1 280	41	D-356
4. New Park Avenue.....	6-in.	1 126	13	D-354
6. New Britain Avenue....	6-in.	1 200	18	D-363

The results of these tests are plotted on Figs. 3, 4, 5 and 6.

No discussion will be attempted, at this time, of the problems suggested by these tests, as it is hoped at a later date to have more information regarding the depreciation in carrying capacity of

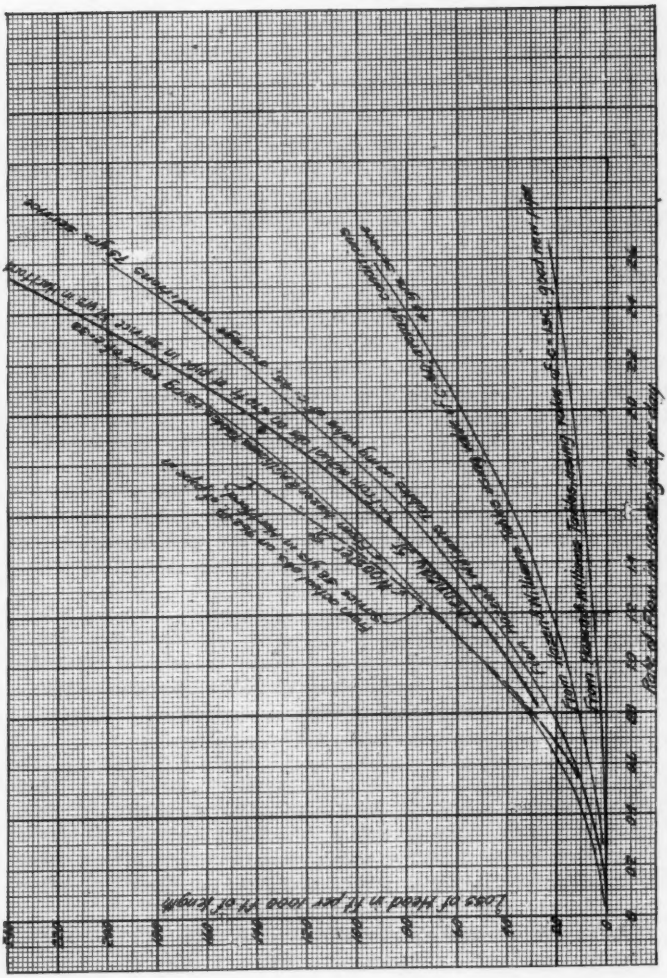

FIG. 3. LOSS OF HEAD IN 4-IN. CAST-IRON WATER PIPE. IN USE OVER 50 YEARS IN HARTFORD.

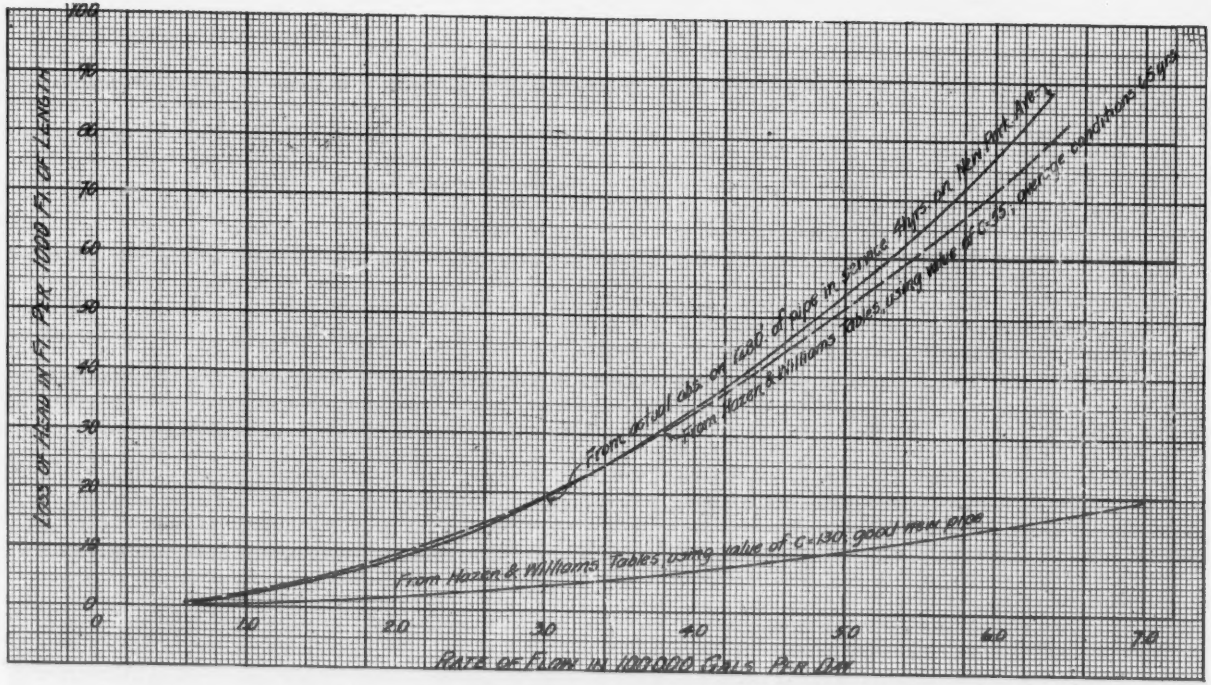
Loss of Head in Ft. per 1000 Ft. of Pipe
Rate of Flow in 100,000 Gals. per Day
From actual obs. on leak of pipe in service 41 yrs. in West Hartford
From Hazen & Williams Tables using value of C=65, average condition of pipe
From Hazen & Williams Tables using value of C=130, good new pipe

FIG. 4. LOSS OF HEAD IN 6-IN. WATER PIPE. IN USE ABOUT 41 YEARS IN WEST HARTFORD.

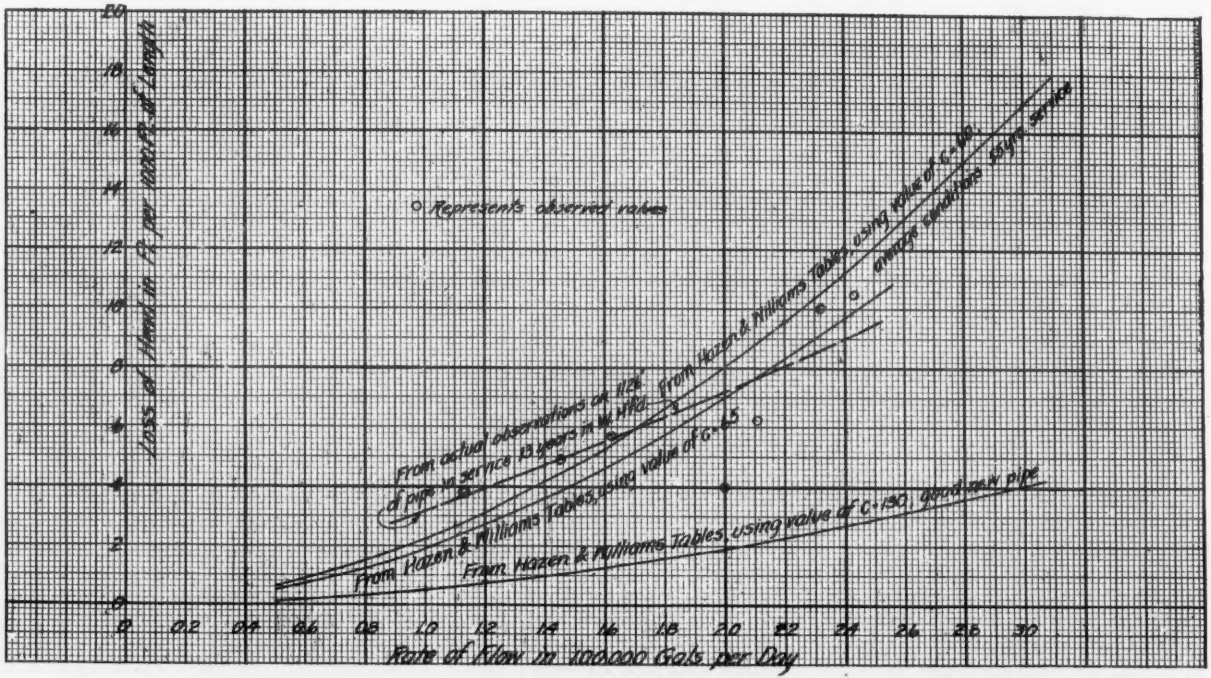
Loss of Head in Ft. per 100 Ft. of Length
Rate of Flow in 100000 Gals per Day
Represents observed values
From actual observations on 12" of pipe in service 13 years in W. Hfd.
From Hazen & Williams Tables using value of C=85, average conditions pipe service
From Hazen & Williams Tables, using value of C=125
From Hazen & Williams Tables, using value of C=150, good new pipe

FIG. 5. LOSS OF HEAD IN 6-IN. CAST-IRON WATER PIPE. IN USE ABOUT 13 YEARS IN WEST HARTFORD.

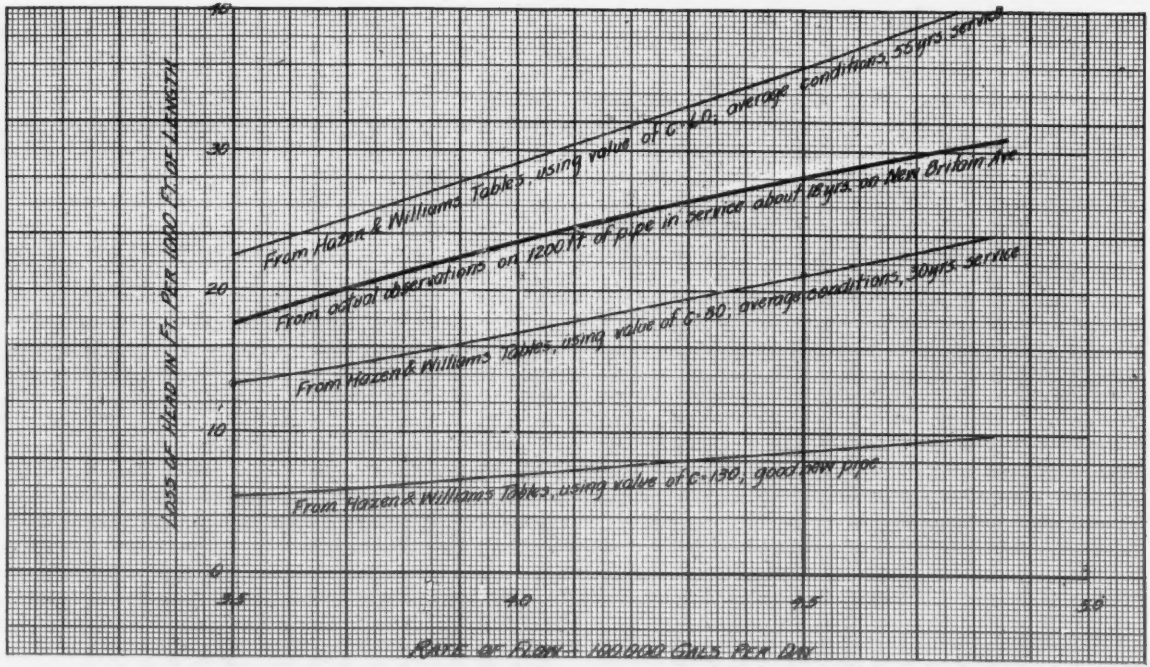
From Hazen & Williams Tables, using value of C=100, average conditions, 35 yrs. service
From actual observations on 1200 Ft. of pipe in service about 18 yrs. in New Britain Ave.
From Hazen & Williams Tables, using value of C=80, average conditions, 30 yrs. service
From Hazen & Williams Tables, using value of C=130, good new pipe
Loss of Head in Ft. Per 1000 Ft. of Length
30
20
10
0
35
40
45
50
Rate of Flow - 100,000 Cubic Ft. Per Day

FIG. 6.—LOSS OF HEAD IN 6-IN. CAST-IRON WATER PIPE. IN USE ABOUT 18 YEARS IN HARTFORD.

cast-iron pipe after period of service under Hartford conditions. In general, it may be noted that the curve derived from experiments follows closely the shape of those plotted from the Hazen-Williams formula, although they do not agree as to age. This difference is probably due to character of incrustation and other impediments of local significance. It is perhaps of interest also to note that a 4-in. pipe about fifty-seven or fifty-eight years old has a carrying capacity equivalent to a smooth pipe $2\frac{1}{2}$ in. in diameter. Such condition must necessarily have a bearing on the matter of estimating present values of pipe lines which have been laid for a number of years. The worth of a distribution system consisting of cast-iron mains should be based on consideration of adequate size, interior condition and salvage value of the pipes, with little or no account being made of actual depreciation of the pipes except by electrolysis or other special conditions.

Testing Distribution Mains.

During the past three months opportunity has been had to test ten sections of new main pipe aggregating nearly two miles in length. This pipe was laid in city streets by the regular maintenance force of the department. The results are tabulated on the following page.

No definite criterion was set for this work, but the results obtained last year from testing $7\frac{1}{2}$ miles of 42-in. cast-iron pipe of the Nepaug supply main were kept in mind. These tests have been referred to by the writer,* and a tabulation of the results and a diagram show the conditions under which the tests were made.

On the basis of nominal diameters, the leakage from this line under test pressure varying from 100 to 125 lb. per square inch was at an average rate of 0.695 gal. per twenty-four hours per linear foot of pipe joint. It is considerable of a conicidence to note that the average leakage per linear foot of pipe joint for twenty-four hours given for the ten sections of distribution pipe tabulated above is also practically the same.

In the specifications for the construction of the Nepaug Pipe

* Journal N. E. W. W. A., XXIX.

TABLE 2.

Data from Tests of Distribution Mains.

Location.	Date.	Size of Main. Inches.	Length. Feet.	Joints on Main Pipe.	Lin. Feet Joint.	Test Pressure Lb. per Sq. In.	Leakage per 24 Hours. Gallons.	
							Total.	Lin. Feet of Joint.
New Britain Ave.	Oct. 29	10	620	54	148*a*	126	140	0.947
Arnoldale Road	Sept. 14	20	2 325	194	1 017	93	130	0.128
New Britain Ave.	Sept. 14	12	1 197	102	320	106	98	0.206
Asylum St.	Sept. 30	12	1 327	115	399*b*	119	432	1.080*k*
Asylum St.	Oct. 16	12	1 070	99	341*d*	125	582*x*	1.700*m*
Seymour St.	Sept. 30	8	1 159	101	224*e*	109	194	0.867
New Britain Ave.	Nov. 12	12	1 054	91	309*f*	125	97	0.313
Allen Place	Nov. 11	8	550	50	113*g*	120	75	0.670
Allen Place	Nov. 5	8	1 076	93	206*h*	120	376*	1.820
Jefferson St.	Nov. 27	8	562	49	109*i*	105	162	1.485
			10 940 = 2.07 mi.		3 086		2 286	0.717

x Ordinary pressure here is 65 lb., leakage at this pressure, 27 gal. per 24 hours.

a Includes 4 6-in. joints. *b* Includes 10 8-in. joints. *d* Includes 4 8-in. and 14 6-in. joints.
e Includes 8 6-in. joints. *f* Includes 15 6-in. joints. *g* Includes 4 6-in. and 2 4-in. joints.
h Includes 6 6-in. and 2 4-in. joints. *i* Includes 4 6-in. joints.
k Includes some leakage at an 8-in. connecting gate. *m* Includes some leakage from an 8-in. gate.

* Large amount probably due to corporation cocks not entirely closed.

Line, the section concerning testing read in part, "The pipe shall be tested . . . under a static pressure corresponding to a water level everywhere of at least 100 ft. above the hydraulic grade line shown on the contract drawings. . . . The entire leakage of any section . . . shall not exceed a rate of 2 gal. in twenty-four hours per linear foot of pipe joint, the length of joint to be figured on the nominal interior diameter of the pipe." The amount here given was decided upon only after careful consideration of the results of tests elsewhere, and the intention was to set such a limit that, on the one hand, excessive joint leakage would be guarded against, and on the other the cost of the work would not be increased considerably by too severe requirements. Observations of working conditions, experience in testing, and the results obtained from the tests showed that the leakage allowable might well have been set at least one half the limits given without calling for any special precaution or unusual care on the part of the contractor.

In his paper before this Association, September 9, 1914, Mr. E. G. Bradbury * proposed as a standard for allowable leakage in cast-iron water pipes an average of 100 gal. per inch mile, equivalent to about 0.8 gal. per foot of lead joint for each complete contract or district, with a maximum of double this for any single test. The testing of pipes discussed in this paper shows that the proposition of Mr. Bradbury would set requirements well within the results which were obtained.

In the tabulation and elsewhere, results are given in terms of linear foot of pipe joint, which seems to be the most logical unit. Nominally, pipe joints are 12 ft. apart; practically, they are seldom or never this distance. For example, on the $7\frac{1}{2}$ miles of 42-in. pipe, the average laying length between joints was 11.75 ft. On the section of distribution pipe given in the table, the laying length has varied from 10.8 ft. to 12 ft. If there are many specials or cut pipe, the laying length may be reduced considerably below that given above. As the unit — "inch diameter per mile of pipe" — must be deduced from the length of pipe joints actually exposed to leakage, the actual number of joints makes considerable difference in the result. Besides this, in almost every line

* Journal N. E. W. W. A., XXVIII, 321.

there are branches and connections having various sized joints differing from those on the main line. These must be considered in getting a unit for expressing leakage. All of these conditions readily fall in with "leakage per linear foot of joint," and for this reason that unit is considered to be well adapted for the purpose of comparing leakage for different pipe lines.

In running tests on distribution mains, sections between gates are ordinarily taken. The intention is to apply about 40 lb. pressure to the section under test in excess of that which ordinarily is to be expected. Wherever possible, the section is subjected to several different pressure heads during the test, with the intention of obtaining data as to the character of the leakage. While the information is not yet complete, the indication is that, with no gates or corporations open or joints blown out, the loss of water, as might be expected with thin openings, varies nearly directly with the pressure. With this in mind it is possible to make very reliable deductions as to the kind of leak to look for when an excessive draft is shown in the test.

The apparatus used in testing is the ordinary force pump for clearing obstructions from service pipes. Usually the pump is a single cylinder, hand-operated force pump, two inches diameter piston and four-inch stroke operating from a small tub. The capacity of this pump under 100 lb. pressure has been found to be about 2 gal. per minute. The quantity passing the pump is measured by an ordinary meter of small size. The cost of testing, including all labor, material, and supervision, has averaged about $6 per test. On the Nepaug pipe line, where conditions were somewhat different, the cost of the work was about four cents per linear foot of pipe, or $200 per section tested. In this case a steam pump was necessary to fill the pipe, and the cost included the setting up and operation of this plant and oftentimes also the laying of long lines of small size pipe.

Foundry Rejections of Cast-Iron Pipe.

During the past four years the Hartford Water Department has purchased about 16 750 tons of cast-iron water pipe. Of this, 10 886 tons was 42 in. in diameter for the Nepaug pipe line and

5 864 tons of sizes varying from 4 to 24 in. in diameter for ordinary needs of the distribution system.

Inspection is paid for at a rate per ton of pipe actually inspected, whether or not accepted on the order. Table 3 gives data concerning the amount of pipe inspected, purchased, and rejected on the smaller-sized pipes for the distribution system, the maximum rejection being 61.9 per cent., and the minimum, 3.2 per cent. In the total it appears that there was an average of about 11 per cent. of rejections; or, in other words, for every ton of pipe accepted, 1.124 tons were inspected. If the inspection charge was 25 cents per ton, this would mean an actual cost of about 28 cents per ton for the net quantity purchased. The causes of these rejections are, of course, oftentimes unavoidable, but an inspection of Table 4 will show that probably careless foundry methods are responsible for a large part of this trouble. Since this matter has been in my mind, I have been watching the reports from the various foundries from which we have purchased pipe and I find that there is considerable difference in the amount and character of the rejections. This being the case, the conclusion seems obvious that, as stated above, carelessness, lack of skilled help, and improper iron mixture are responsible, in part at least, for a large number of rejections. If this is so, a method of correction, perhaps, would be to set a limit to the total amount of rejections that would be allowed and deduct from the pipe bill the amounts of the inspector's charge in excess of this amount. As a question for discussion, I would suggest 10 per cent. as the maximum amount of rejections to be paid for by the purchaser, amounts in excess of this to be borne by the foundry. An alternative of this suggestion might be to allow the foundry to submit only such pipe as they choose for inspection, and then to charge against the foundry all cost of inspection in excess of, say, 5 per cent. The reason for setting 10 per cent. as the limit was reached after study of the percentages from the several foundries. It was found that about 3 000 tons, or 45 per cent. of the total inspection shown in Table 3, varying in sizes from 4 to 20 in. in diameter, was furnished by one company. Of this amount of pipe, 75 per cent. was passed with 7.5 per cent. or less rejections, and 33 per cent. with less than 5 per cent. rejections. Some such action as

TABLE 3.

INSPECTION OF CAST-IRON PIPE AND SPECIAL CASTINGS, HARTFORD WATER WORKS.

(Class E, N. E. W. W. Specifications.)

1912–1915 inclusive.

Size. Inches.	Quantity in Tons.			Per Cent. Rejected.	Tons Inspected for Each Ton Accepted.
	Inspected.	Accepted.	Rejected.		
	Straight Pipe.				
4	141.92	111.69	30.23	21.3	1.213
4	16.37	6.22	10.15	61.9	2.631
4	23.52	20.85	2.67	11.2	1.123
6	17.39	14.58	2.81	16.2	1.192
6	162.80	140.35	22.45	13.8	1.160
6	47.54	39.35	8.19	17.2	1.208
6	22.11	17.18	4.93	22.4	1.287
6	20.52	18.54	1.98	9.4	1.109
6	24.23	20.16	4.07	17.0	1.201
6	26.34	21.79	4.55	17.5	1.208
8	89.46	71.71	17.75	19.8	1.248
8	357.71	320.97	36.74	10.3	1.114
8	116.88	98.42	18.46	15.8	1.188
8	300.48	283.39	17.09	5.7	1.062
8	798.36	744.98	53.38	6.7	1.072
10	513.50	360.16	153.34	29.8	1.425
10	419.27	355.88	63.39	15.1	1.178
10	206.09	190.99	15.10	7.5	1.079
10	282.91	266.25	16.66	5.9	1.064
10	41.80	38.17	3.63	8.6	1.094
12	397.76	334.65	63.11	15.8	1.188
12	141.23	111.69	29.54	21.0	1.261
12	632.11	604.44	27.67	4.4	1.047
12	412.89	379.36	33.53	8.3	1.089
16	131.63	111.85	19.78	15.0	1.176
16	84.49	81.79	2.70	3.2	1.030
16	377.43	364.91	12.52	3.3	1.034
16	122.94	117.70	5.24	4.3	1.045
20	284.85	258.35	26.50	9.4	1.103
24	373.92	357.49	16.43	4.4	1.046
Total	6 588.45	5 863.86	724.59	11.0	1.124
	Special Castings.				
	24.84	19.92	4.92	19.7	1.242
	77.88	62.29	15.59	20.0	1.256
	137.41	100.02	37.39	27.3	1.374

TABLE 4.

FOUNDRY REJECTIONS.

March 15, 1915, to July 24, 1915.

4-in. pipe inspected, 23.52 tons.
6-in. pipe inspected, 24.23 tons.
8-in. pipe inspected, 798.36 tons.
10-in. pipe inspected, 262.25 tons.
12-in. pipe inspected, 412.89 tons.
16-in. pipe inspected, 122.06 tons.
20-in. pipe inspected, 284.85 tons.

Total amount of pipe inspected, 1 928.16 tons.
Special castings inspected, 79.92 tons.
Pipe are Class C, and special castings are Class D.

Defect	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	20-in.	Specials
Bead bad		1.06	31.19	0.45		1.75		
Bead broken								0.14
Bead raised		0.44	2.16					
Bell bad	0.15							0.47
Bell dirty				5.67	3.32		5.11	
Blistered								1.18
Blowed						0.88		1.56
Blow hole				0.45	0.57			0.20
Coke ring bad			0.32					
Core bad			1.56					
Core blister					0.57			
Core cut								0.11
Core rake				0.88				
Core ring			3.80					
Core rough		0.44						
Core scabs			0.94		22.93		11.20	
Core swells	0.29							
Cracked		0.63	0.32		0.57			0.34
Crooked			0.31					
Crushed								1.28
Dead iron							1.26	0.26
Dirty								0.07
Dirty b. face						0.88		
Dirt hole				0.43				3.91
Head crushed		0.21				0.85	2.55	
Head cut							1.23	
I. ring bad			0.31					
Iron inside	1.96							
Light	0.13		1.47					
Mold bad		0.22	0.31					
Mold cut				0.44	0.45		2.57	
Mold rough				1.33				
Mold scabs	0.14			0.44				
Mold strain			2.19	0.44				
Poured short				1.31				
Run out				0.43		0.88		0.15
Scabbed								1.38
Socket bad								0.14

TABLE 4. — *Continued.*

Defect.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	20-in.	Specials
Socket cut.....			4.41	0.44				
Socket short.....								0.40
Soft rammed								0.20
Spawled.....								0.15
Thin.....								1.17
Uneven.....		1.07	4.09	3.95	1.12		2.58	2.48
Totals.....	2.67	4.07	53.38	16.66	33.53	5.24	26.50	15.59

Total amount of pipe inspected, 1 928.16 tons.
Total amount of pipe rejected, 142.05 tons.
Total amount of pipe purchased, 1 786.11 tons.
Percentage pipe rejected of pipe purchased, 7.9 per cent.
Ratio tons inspected to tons accepted, 1.07: 1.00 tons.

Note. — All the above except the 4-in. pipe were bought on contract.

Special Castings.
Tons inspected, 79.92.
Tons rejected, 15.59.
Tons purchased, 64.33.
Pipe rejected to pipe inspected, 19.5 per cent.
Tons inspected to tons accepted, 1.24 tons.

this, I feel sure, would have a tendency to result in fewer rejections and a better class of pipe in the foundries where the present percentage of rejection is quite large. Such conditions, as noted above, indicate also the necessity of careful inspection at the foundry, whether the pipe be cast on order or taken from the stock pile. This reference to foundry shortcomings in no way reflects on cast-iron pipe itself, which I believe to be the best material which has been proposed thus far for distributing water. Neither do these criticisms apply equally to all foundries and makers of cast-iron pipes. Every foundry can turn out first-class products if so desired. Several of them are ordinarily supplying such a high grade of goods that competent purchasers prefer to place orders with them without competition when specially important work is to be undertaken.

Tables 5, 6, and 7 apply to 42-in. pipes purchased for the Nepaug pipe line. Inspection shows that the rejections on this purchase were very reasonable in amount, that percentage of cut pipe was not excessive, and the variation in weight was within the limits stated in standard specifications.

TABLE 5.

CONTRACT 4-A.

	Straight Pipe. Tons.	Specials. Tons.
Total weight inspected	12 049.27	109.9955
Total weight paid for	10 885.88	98.1945
Weight rejected	1 163.39	11.8010
Rejection of total cast	9.6 per cent.	10.7 per cent.
Total number of pipes accepted		3 294
Total number of pipes rejected		352
Per cent. rejected		9.6

TABLE 6.

SUMMARY OF PRINCIPAL CAUSES OF REJECTION OF 42-IN. PIPE FOR CONTRACT 4-A.

Cause of Rejection.	Number Rejected for This Cause.
Mold scabs	42
Core crushed	36
Core buckled	7
Sand hole	19
Shrunk hole	8
Shrunk gate	23
Uneven — light or thin	36
Bad bell	24
Bad bell face	10
Bad bead	17
Socket cut	7
Light	60
Heavy	1
Leaked	26
Miscellaneous	36
Total	352

LOSSES IN FIRE HYDRANTS.

Recently, two tests have been made in Hartford to determine the capacity of the supply and distribution system under conditions of very large draft. Very interesting data were obtained, some of purely local application and other of more general interest. From this latter class is taken the matter of losses in fire hydrants. The hydrant used was a 5-in. standard make. The

TABLE 7.

TOTAL NUMBERS AND WEIGHTS OF 42-IN. CAST-IRON PIPE RECEIVED ON CONTRACT 4-A.

Received at	Class of Pipe, N. E. W. W. A. Specifications.										Specials.	
	B.		C.		D.		E.		F.			
	No.	Weight.*	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.		
Burlington			224	711.09	49	169.77	16	61.78	15	64.28	8	10.69
Brick Yard	228	628.36	552	1 760.88	515	1 823.61			20	84.87	23	33.46
Unionville	273	763.32	684	2 183.28	670	2 372.62	34	133.73	14	59.26	48	50.50
Totals	501	1 391.68	1 460	4 655.25	1 234	4 366.00	50	195.51	49	208.41	79	94.65
Av. wt. per length†	5 555		6 377		7 076		7 820		8 506			
Std. wt., do	5 560		6 270		6 970		7 720		8 360			
Per cent. variation†	—.05		+1.7		+1.52		+1.29		+1.75			
No. foundry cut and av. laying length	34 (11–6)		87 (11–6½)		17 (11–6½)		5 (11–7½)		1 (11–7¾)			
Per cent. of cut pipe	6.7		6.0		1.4		10.0		1.0			

* Weights are in tons. † No allowance made for cut pipe.

TABLE 8.

TEST OF 5-IN. FIRE HYDRANT OF "H" PATTERN WITH FOUR 2½-IN. NOZZLES AND ONE STEAMER NOZZLE.

Test No.	No. of Streams.	Hose No.	Size of Hose Nozzle.	Nozzle Pressure by Pitot Tube Gage Lb. Sq. In.	Discharge through Nozzle Gals. per Min.	Losses in Pressure. (Det. by mercury differential gage.) Main to Hyd. Branch. A to B. In Hg. / Lb. Sq. In.	In 26′ of 8″ Hyd. Lateral. B to C. In. Hg. / Lb. Sq. In.	In Foot of Hydrant. C to D. In. Hg. / Lb. Sq. In.	In Barrel of Hydrant. D to E. In. Hg. / Lb. Sq. In.	Pressures. In 24″ Main A. Lb. Sq. In.	In Hyd. at E. Lb. Sq. In.	In Hose No. 4 at Hyd. Lb. Sq. In.
1	1	1	1⅛″	67	305	1/16″ = 0.03	⅛″ = 0.06	½″ = 0.23	0″ = 0	..	..	..
2	2	1 2	1¾″ 1¾″	38 41	560 585 1 145	1″ = 0.45	1 5/16″ = 0.60	7½″ = 3.4	½″ = 0.23	81	75	..
3	3	1 2 3	1¾″ 1¾″ 2″	32 38 26	515 560 610 1 685	2¼″ = 1.02	2½″ = 1.14	16¾″ = 7 6	1¼″ = 0.57	82	69	..
4	4	1 2 3 4	1¾″ 1¾″ 2″ 1¾″	32 37 26 35	515 552 610 538 2 215	3¾″ = 1.71	4¾″ = 2.16	*12.3	2″ = 0.91	80	61	53

5	5	1	$1\frac{3}{4}''$	31	507	$5\frac{3}{16}''=2.36$	$6\frac{1}{4}''=2.84$	*16.8	$3''=1.36$	81	57	49
		2	$1\frac{3}{4}''$	34	530							
		3	$2''$	24	584							
		4	$1\frac{3}{4}''$	31	507							
		5	$2''$	18	505							
					2 633							
6	6	1	$1\frac{3}{4}''$	25	454	$6\frac{1}{2}''=2.95$	$7\frac{3}{8}''=3.35$	*20.8	$3\frac{1}{4}''=1.48$	81	51	43
		2	$1\frac{3}{4}''$	28	481							
		3	$2''$	20	532							
		4	$1\frac{3}{4}''$	28	481							
		5	$2''$	17	490							
		6	$2''$	17	490							
					2 928							

NOTE. Hoses Nos. 1, 2, 3, and 4 attached to hose outlets. Hoses Nos. 5 and 6 siamesed to steamer outlet.

* Losses obtained from readings of pressure gages at C and at D as follows:

Test No.	Pressures. Lb. per Sq. In.			Correction for Difference in Elevation of Gages at C and D.	Corrected Loss, C to D.
	Gage at C.	Gage at D.	Difference.		
4	76.5	65	11.5	1′ 10″ = 0.8 lb. sq. in. to be added	12.3
5	74	58	16	0.8	16.8
6	72	52	20	0.8	20.8

NOTE. Hydrant was on west side of Trumbull Street, opposite Gold Street. One 50-ft. length of $2\frac{1}{2}$-in. hose was attached to each $2\frac{1}{2}$-in. hydrant nozzle, and two 50-ft. lengths were siamesed to the steamer nozzle.

test was run to an extreme limit of discharge. The results obtained do not specially reflect on this type of hydrant, which our

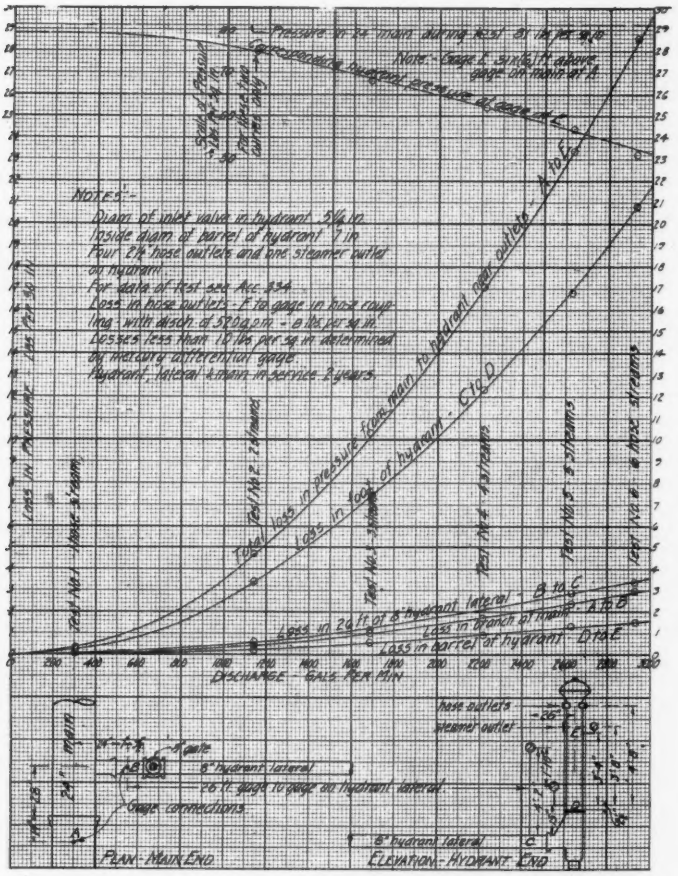
Pressure in 24" main during test 81 lbs per sq in
Corresponding hydrant pressure at gage at C
Note - Gage 2 ins (1 ft) above gage on main at A
Notes:-
Diam of inlet valve in hydrant 5½ in
Inside diam of barrel of hydrant 7 in
Four 2½ hose outlets and one steamer outlet on hydrant
For data of test see Art. 334
Loss in hose outlets - 1" tip gage in hose coupling with discharge of 520 g.p.m. - 8 lbs per sq in
Losses less than 10 lbs per sq in determined by mercury differential gage
Hydrant, lateral & main in service 2 years
Total loss in pressure from main to hydrant with outlets - A to D
Loss in 100 ft of hydrant - C to D
Loss in 26 ft of 8" hydrant lateral - B to C
Loss in branch at main - A to B
Loss in barrel of hydrant - D to E
Test No 1 - 2 hoses
Test No 2 - 3 hoses
Test No 3 - 4 hoses
Test No 4 - 5 hoses
Test No 5 - 6 hoses
Test No 6 - 8 hoses streams
Loss in Pressure
DISCHARGE GALS PER MIN
hose outlets
steamer outlet
24" main
A gate
8" hydrant lateral
26 ft gage to gage on hydrant lateral
Gage connections
PLAN - MAIN END
ELEVATION - HYDRANT END
PRESSURE LOSSES IN 5" FIRE HYDRANT ON TRUMBULL ST. OPP GOLD. AUG. 17, 1915

FIG. 7.

experience has shown to be very satisfactory, but are given here as applicable in a greater or less degree to most hydrants now on

the market when used under the conditions of the test herein described.

The data presented indicate what limits of discharge and loss of pressure may be expected under a range of draft. It is believed that the test was made absolutely under working conditions of service, and the data may be taken as of practicable application without the refinements of a testing laboratory.

The data and results are shown in detail in Table 8 and in Fig. 7.

A description of the test and the conditions under which it was made may be very briefly stated.

The hydrant was located in a portion of the congested district, and at a point where the ordinary pressure is quite high. The water drawn from the hydrant was discharged into the Park River which flowed nearby. During the final run, 6 hose streams were in service, 4 connected to the 4-hose outlets of the hydrant, and 2 siamesed to the $4\frac{1}{2}$-in. steamer outlet. No special preparation was made for this test, as the intention was to get working conditions as far as possible. The maintenance force of the Water Department excavated the trench of the hydrant lateral which had been laid about two years and tapped in gage connections as shown on the plan and elevation at the bottom of Fig. 7. Mercury differential gages were used when the differences in pressure were rather small, and pressure gages when the difference was too large to be read on the mercury columns. Members of the engineering staff affixed the gages and operated them throughout the test. Fire department men did all the work connected with hose operation under the personal direction of the fire chief, whose interest, intelligent coöperation, and desire to obtain facts applicable to fire department matters has been of the greatest assistance.

The principal loss is in the bottom of the hydrant, starting with an inappreciable amount with one hose stream of about 300 gal. per minute and reaching a loss of nearly 22 lb., or 73.5 per cent. of the total, when the discharge was 3 000 gal. per minute. The advantage of the large lateral from the main to the hydrant is shown by the small losses which occurred there, under maximum flow the loss in the branch and lateral being less than 5 per cent. of the total. Incidentally, it appears that the loss in a 24

by 6 branch is about the same as that in 30 ft. of 8-in. pipe, there being probably some slight loss in the 8-in. gate on the lateral. The hydrant barrel seems of ample size.

The principal conclusion to be drawn from this test seems to be that the water-way at the base of the hydrant should be of more ample proportion, devoid of obstructions so far as possible in the matter of valves and stems and provided with smooth, easy passage for changing the direction of the incoming water. It seems desirable to have large-sized laterals, and a size larger branch from the main with a reducer to the lateral would be of considerable advantage even if a smaller lateral were used.

PUBLIC USES OF WATER.

The average daily consumption of water in Hartford is at a rate of about 9.5 m.g.d., which, with the number of consumers estimated at 143 500, gives a per capita consumption of 65.5 gal. per day. Hartford may be taken as a fully metered city, all of the services being so covered except those intended solely for fire protection purposes. A recent canvass of public uses of water, and a comparison of Venturi meter records from the supply lines with the amount of water paid for, has resulted in the following estimate of the manner in which water is disposed of in this city. On account of the roundabout methods by which some of the figures were obtained, the tabulation is subject to correction when more reliable data are at hand, but those given now are thought to give a substantially correct classification.

DIVISION OF USE OF WATER IN THE CITY OF HARTFORD.

Use.	Million Gallons per Day.	Gallons per Capita.	Per Cent. of Total Consumption.
Domestic	4.74	33.0	50.4
Manufacturers and other business	2.73	19.0	29.0
Public	0.43	3.0	4.6
Unaccounted for	1.50	10.5	16.0
	9.40	65.5	100.0

In connection with the matter of the per capita consumption of water, it is interesting to compare the above figure with the

estimate made by the late Mr. Dexter Brackett in his report on "Present and Future Consumption of Water in the Metropolitan District in Boston."

Use.	Gallons per Capita.
Domestic	35
Trade and mechanical	35
Public	5
Leakage and waste	25
	100

Regarding the last item, Mr. Brackett stated that he considered an allowance of 15 gal. per inhabitant for leakage and waste a minimum quantity which could only be maintained by a thorough meter system and constant inspection. As Mr. Brackett was a recognized authority on this subject, and his estimates for the Metropolitan District fully justified, it would appear that water conditions in the city of Hartford are at least normal.

PUBLIC USES.
(Approximate only, and subject to considerable revision.)

Service.	Amount per Year.		
	Million Gallons. Total.	Million Gallons per Day.	Gallons per Capita.
Fire			
Station use	3.7	0.010	0.074
Extinguishing fires	3.3	0.009	0.066
			0.140
Parks	11.7	0.032	0.235
Police	0.9	0.003	0.022
Street			
Drinking fountains	0.4	0.001	0.008
Horse fountains	2.3	0.008	0.059
Sprinkling and flushing	34.1	0.093	0.684
Miscellaneous	0.4	0.001	0.008
			0.759
**Schools*	24.7	0.068	0.498
Miscellaneous buildings	20.8	0.057	0.419
	102.8	0.282	2.073

* Including parochial schools.

Fire Department. The general public seems to have an impression that vast quantities of water are used in the putting out of fires. This is a very erroneous idea, as the total amount of water so used is comparatively small. The rate of demand, however, for short periods is often very great, so great, in fact, that in cities of 100 000 to 150 000 population a reasonable requirement for fire protection service often equals or exceeds the maximum hourly rate of draft of an ordinary day. The total amount of water used by the Fire Department of Hartford in the past year was about 7 million gallons, or a little over a pint per capita per day, of which about one half was used in the maintenance of 16 stations, including washing of hose and apparatus. The remainder was used in the extinguishing of fires.

The following data from Fire Department records of 1914 is an indication of service conditions in this city.

Total actual fire alarms	628
Number fire calls at which water was used	105
Number of times pump service available	63
Number of hose streams in use, average	2
Length of hose line, average, feet	380
Usual size nozzle, inches in diameter	1 to 1¼
Average hydrant pressure in service	60 to 80 lb.
Average pump pressure	100 to 200 lb.
Total amount of water used	3 300 000 gal.
Value of property included in the fires	$7 973 109
Insurance thereon	$3 348 310
Insurance loss	$14 590

The following table shows the duration of hose service at fires in 1914.

Number of Fires.	Duration of Service.
50	15 minutes.
25	15 minutes to 30 minutes.
15	30 minutes to 1 hour.
11	1 hour to 2½ hours.
2	2½ hours to 4 hours.
2	4 hours to 6 hours.

Of the 105 alarms at which water was used, three or more streams were in service at only 16. There were seven calls at

TABLE 9.

ANALYSIS OF THE SEVEN CALLS WHERE FIVE OR MORE STREAMS WERE IN SERVICE.

Date. 1914.	No. Streams.		Length of Time in Service.			Discharge of Stream. Gallons per Min.			Max. Rate of Discharge.			Equiv. No. 250 g.p.m. Streams.	Estimated Total Amount Water Used. Gallons.
	2½ in.	3 in.	Aver. h. m.	Min. h. m.	Max. h. m.	Aver.	Min.	Max.	h. m.	g.p.m.	m.g.m.		
Jan. 20.....	9	–	4 20	3 —	6 —	260	240	285	3 —	2 360	5.40	9.5	613 370
Feb. 21.....	11	2	2 35	2 —	4 30	365	175	645	2 —	4 765	6.86	19.1	648 380
Feb. 26.....	8	2	2 20	1 —	4 15	315	260	425	1 —	3 130	4.50	12.5	426 530
May 23.....	5	–	– 30	– 10	1 25	225	200	270	– 10	1 120	1.61	4.5	35 770
Dec. 4.....	3	2	1 25	– 35	4 —	335	260	450	– 35	1 665	2.40	6.7	151 220
Dec. 4.....	7	2	1 25	– 35	2 10	325	245	565	– 35	2 930	4.22	11.7	239 670
Dec. 18.....	5	–	– 55	– 15	1 30	270	210	300	– 15	1 340	1.93	9.3	67 250

These seven fires used a total of 2 182 190 gal., or about two thirds of the entire amount used to put out fires, leaving 1 117 810 gal. to be used by the other 98 calls, or an average of about 11 400 gal. per fire call.

which 5 or more streams were used, four at which 9 or more were used, and one at which 13 streams were in service.

An analysis of the seven calls at which five or more streams were in service is given on the preceding page, in Table 9.

The largest fire, that of February 21, was in the Union Station, — a sandstone structure with wooden finish and generally large open room space. This building had streets on three sides and an open four-track space on the other. It was, therefore, very easy to reach with water, not difficult to curtail spreading to adjacent buildings, and, due to its stone sides, practically self-contained. The water pressure from the hydrants was at about a maximum, due both to the relatively low elevation of the ground and to the fact that the fire came in the afternoon. With different surroundings and adverse conditions, 50 per cent. more fire streams might easily have been required to keep the fire from spreading. This would have been 28 250-gal. streams, a requirement well within the limits set by the fire insurance underwriters for a city the size of Hartford, and yet this was not a fire that at any time threatened a conflagration.

Under topic "Throttling Gates," page 207, reference is made to a fire in a hay and grain storehouse; this fire was referred to by the writer in his paper on "Water Ram,"* and a table given there is reproduced below in order to show what amounts of water may be called for in an ordinarily bad fire. The Venturi meter on the supply main at the effluent gatehouse indicated a draft for this fire of about 350 000 gal., the rates of draft in excess of the ordinary consumption being as follows:

Ten-Minute Intervals.	Gallons per Hour.	Ten-Minute Intervals.	Gallons per Hour.
1st period	125 000	9th period	110 000
2d	190 000	10th	130 000
3d	200 000	11th	140 000
4th	240 000	12th	100 000
5th	195 000	13th	70 000
6th	160 000	14th	30 000
7th	170 000	15th	20 000
8th	170 000	16th	30 000

*Journal N. E. W. W. A., XXVIII, 185.

It is of interest to note in this connection that in a city of 135 000 inhabitants, with full fire and police protection, there is a possibility during any year of at least five fire calls any one of which may require from 150 000 to 650 000 gal. of water drawn at rates up to nearly seven million gallons per day in excess of a maximum ordinary flow. Also that this rate may be maintained for two to three consecutive hours. In view of the Baltimore, Chelsea, and Salem conflagrations, and the ordinary fire demands of a city the size of Hartford, it seems clear that it would be very well for many towns and cities to look very closely into the capacity of their supply mains.

Park Department. The city of Hartford is noted for the extent and beauty of its parks. Expense has not been spared to develop this wonderful and delightful system, which is thrown freely open to the public with the endeavor to make these open places the people's recreation grounds. The total park area is about 1 325 acres, part of which is in natural wooded condition and part intensively cultivated. The total amount of water used by this department for park purposes was 11.9 million gallons, or about 1 quart of water per day per capita; of this, 8.55 million gallons were used in the House of Comfort and in four public bath houses.

Police Department. The use of water for this department is confined to one central station. The total force comprises about 250 members, all of whom when on duty report at the central station. The total amount of water used by this department is about 900 000 gal. per year, or about 0.022 gal. per capita based on city population. Based on the force reporting to this station, the use of water is about 12 gal. per day, including all purposes.

Street Department. The total amount of water used by this department is estimated to be 37 700 000 gal. per year, or about three fourths of a gallon per capita per day based on population. This use comprises that required by 14 drinking fountains, 12 horse troughs, the sprinkling and flushing of streets, and miscellaneous uses such as stables, yards, and sewer flushing. As a general rule, street sprinkling and flushing continues for from $7\frac{1}{2}$ to 8 months per year. During the winter season the number of fountains and troughs is considerably reduced. During nearly two thirds of the year about 320 250 sq. yd. of asphalt paving are

flushed nightly, and about two miles of 30-ft. roadway regularly sprinkled. As bearing on this subject it is pertinent to state that a very large proportion of the macadam streets in Hartford are oiled and therefore use little or no water during the season.

Schools. The total use of water in the schools of Hartford amounts to about 24.7 million gallons per year, or about three quarters of a gallon per capita of estimated population. Of the schools using water, there are 19 public schools using 18.8 million gallons per year and 13 parochial schools using 6.0 million gallons for the same period. The total number of children of school age is estimated as 24 456. The school year extends over forty weeks, from the Friday following the second Wednesday in September, comprising about 210 actual school days.

The following table gives data on the consumption of water in the public schools of the city, the attendance being taken from the report of the Board of School Visitors of the City of Hartford for the year 1914.

District.	Total Average Attendance.			Total. Mil. Gal. per Year.	Gallons per Capita, Attendance per School Day.
	Scholars.	Teachers.	Total.		
Brown	1 589	47	1 636	2.66	7.75
South	4 182	144	4 326	3.52	3.88
Second North	1 380	54	1 434	1.25	3.74
West Middle	958	44	1 002	.86	2.61
Arsenal	1 514	58	1 572	.50	1.52 (min.)
Washington St.	1 177	45	1 222	.88	3.32
Southwest	243	13	256	.35	6.49
Northeast	1 211	46	1 257	1.63	6.68
High School	1 823	104	1 927	6.29	15.57 (max)
	14 077	555	14 632	17.94	5.84 (av.)

The average consumption per scholar in the public schools is 3.5 gal. per day per calendar year.

Miscellaneous Buildings. This use includes the Almshouse, City Hospital, House of Comfort, City Hall, Municipal Building, Halls of Record, Isolation Hospital, and a few minor consumers. By far the largest consumers are the Almshouse and City Hospital,

using 57 per cent. of the total amount credited to miscellaneous buildings.

DOUBLE CHECK VALVES.

You all remember the famous advice to young men about to be married. That same advice in capital letters might well be given to water departments about to introduce the so-called dual system of connections for fire protection between a polluted auxiliary source and a public water supply. With the advice, however, the analogy ends abruptly, for many a mediocre man has been put on his feet by a good wife, but, in my opinion, a dual connection can never be anything but a disease spot in a water-works system.

Many cases of serious pollution of the city supply, and consequent epidemics of typhoid fever, record the failure of automatic devices to work when the crucial test comes, and the only absolutely safe course is to allow no such connection. Reference without further discussion need only be made to typhoid epidemics at Circleville, Ohio; Lowell, Mass., and others due to industrial connections with an infected source.

If dual connections must be used, the form designed by the Associated Factory Mutual Fire Insurance Companies in my opinion offers the best chance for preventing polluted water from entering the city mains. Briefly described, it consists of two check valves with gages and vent pipes so arranged that it is possible to test the valves and ascertain if they seat tight at the time inspection is made. (Figs. 8 and 9.)

Under normal conditions, valves *A* and *G* are open and *B* and *E* are closed.

The test to check valves for leakage, close *A*, open *E*, and open petcock at gage 4 and drain pipe between *A* and *D* through *E*. If *A* is not tight, there will be a continuous flow through *E*. Start fire pump and maintain pressure at about 100 lb., open *B*, and any leakage is through *C*. Connect hand pump at *B*, raise pressure on gage to popping point on relief valve. Any leakage through *E* is from check *D*. Another method of testing is to close valve *A* and open petcock on gage *X*; if check *D* leaks, gage *Y* will drop, and if check *C* leaks, gage *Z* will drop also. If gages *Y* and *Z* do not fall, it may be that check *D* is tight and check *C* leaks.

To test this, open petcock on gage Y; if check C leaks, gage Z will drop. There is a check valve on the discharge end of the fire pump, to keep water from the city main from wasting by the

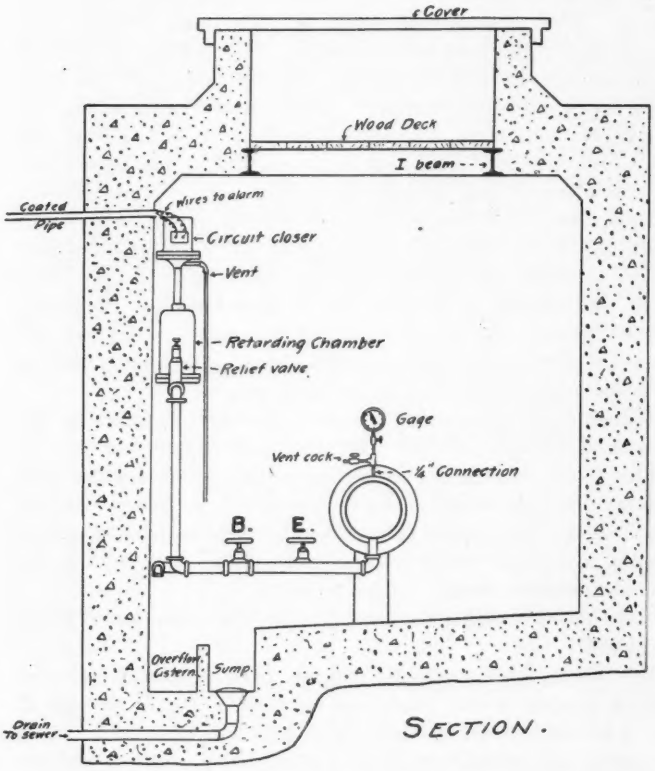

FIG. 8. DOUBLE CHECK DEVICE.

pump. This valve also should be inspected for waste. Beside the above mechanism, there is an electric alarm connected with the check valves, by means of which a bell is rung whenever river

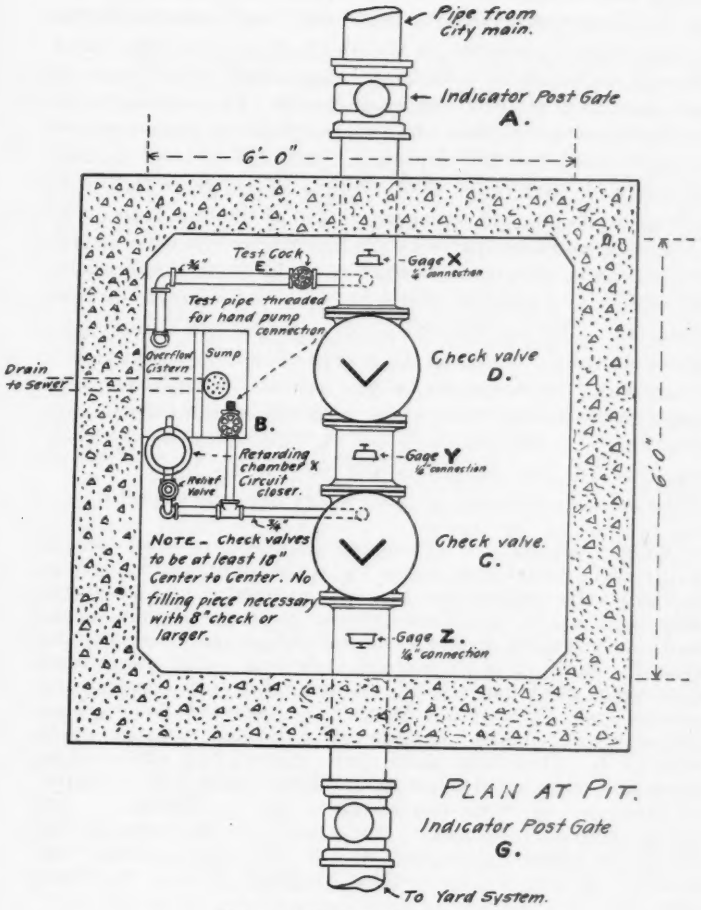

FIG. 9. DOUBLE CHECK DEVICE.

water enters between the checks. Thirteen of these devices govern as many connections to the city water mains in Hartford. To the present time, as far as is known, river water in quantity

has not been injected into the distribution system, and only in a very few cases has any serious fault been found with the checks. Eternal vigilance, however, is always the price of success, and a thorough inspection by a competent and reliable man is made of each connection at least once each month. The manufacturers installed these connections at their own expense, make required repairs, and pay for each inspection. Only the greatest courtesy and desire for coöperation has been experienced where these connections are in use, and whenever notified of the least fault, in no case has expense been spared by the manufacturer to make repairs at once and to the entire satisfaction of the Water Department. The insurance inspectors also have been very earnest in their endeavors to perfect the check-valve system and maintain its proper operation. So far as the present operation of these valves is concerned, there can be no just criticism whatsoever. The danger lies in having them at all, with the constant threat that some time or other somebody will be careless and an epidemic start that will cost many lives and much illness.

The following is a very common report from the inspector:

"Check valves at . . . Company inspected; one set located in driveway; found both valves tight and alarm valve working. Had both valves taken apart, cleaned, and retested, and left everything tight and O. K. Tested checks in pit in sidewalk; found inside valve leaking slightly; had both taken apart, cleaned, and retested. Inner valve still showed slight leak. Had valve taken apart again and found a little rust under disk seat; cleaned, and retested and left O. K." Another: "Inspected 8-inch check valves on . . . Works. Outside valve leaking a little; inside valve O. K. Had both taken apart, cleaned and after putting in new seat rings, found valves tight. Alarm valve O. K." Again: "Tested set of 8-in. check valves at . . . Works, . . . St. Found outside check leaking very badly, inside valve leaking slightly. Cleaned valves, put in new seat rings, retested and found O. K. Alarm not working; notified Mr. . . . to repair same."

The above are from regular monthly reports and show conditions a month after a previous similar test.

Usually all that is necessary is to clean a little rust or slime from the valve seat. Once in a while a more difficult condition is

encountered, and the following excerpt from the records is the most aggravating case that we have experienced recently:

"On regular inspection of the double check valve fire services early in April last, the outside check valve at the . . . Company factory was found to be leaking slightly. After it was cleaned and new seat rings had been put on the disks, it was retested and found O. K. On May 26, in company with insurance company representative, the Water Works Inspector examined this valve. It was again found to be leaking and the manufacturer was notified by letter to have the valve put in good order. On June 1 a telephone message was received from the makers of the valve to the effect that the valve was now in good order, and that the trouble was that the man who had inspected it did not know how to put it together again. The Water Works Inspector was directed to go with a representative of the makers of the valve to the factory and inspect the valve again. It was found to be leaking, and one of the maker's representatives took it apart but could not locate the trouble and put it together again, using shellac to make the rubber seat hold to the disk. After fifteen minutes the valve was tested again and found to be tight.

"On the next visit of the insurance company's representative, however, the valve was found to be leaking again, and an inspection on June 3 showed it still to be leaking. In reply to our letter of June 7, advising them to have the valve put in good working order, the manufacturer replied that they did not know what the trouble with the valve was, but had put the matter up to the makers of the valve, who had promised to have it repaired by Monday, the 14th, at the latest, and if it could not be repaired orders had been given to put in a new valve. On June 14 the valve was tested again and found to be O. K., the makers' representative stating that the trouble was that the cover of the armhole had been binding on the disk, and when relieved the disk seated.

"On the regular inspection trip in August, this valve was again found to be leaking, and a representative of the manufacturer was notified to have same repaired. On August 25, after notice that this valve had been repaired was received, it was again tested and found incapable of holding the pressure.

"On September 7, in company with an insurance company inspector, the check was again examined and the inspector thought that he had found the cause of the trouble, but on September 10 the valve did not hold pressure. On that day, the insurance company inspector and the makers' representative removed the disk and weighted it with lead. On test after this was done, the valve was found to be tight. On the regular inspection trip, a

short time afterwards, the Water Works Inspector was accompanied by an inspector of the insurance company, and when this valve was visited it was found tight."

Abstracts of inspection reports are given in the text to show the liability of the valves not to seat perfectly even under constant care and inspection. With this case the leak was probably infinitesimal, and in nearly every other case only one of the valves has been faulty. Nevertheless, the danger is present. Our experience shows that both check valves might, and under right conditions of water would undoubtedly, fail to seat due to corrosion on the seats, stiffness in the hinges, or a number of other causes.

The following bibliography, in reference to pollution of public water supplies through industrial connections governed by check valves, is given for the purpose of aiding search for data relative to this matter:

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Kewes *v.* City Mankato, 113 Minn. 55, 1910.

DISCUSSION.

GEORGE A. JOHNSON.* Mr. Saville has closed his interesting and instructive paper with some very pointed remarks anent check valves in dual systems of connections in distribution systems. In general the speaker agrees with him. Probably no piece of water-works equipment, with the possible exception of automatic control valves, has as warrantably acquired a man-size anathema as has the check valve on dual connections.

Reduced to its lowest terms, such things in a water distribution system mean that fire protection was the primary consideration. Not infrequently it happens that check valves are found on auxiliary connections to a pure water supply. Then, of course, there is no hygienic objection to them. More commonly, though, the auxiliary supplies are polluted, and it is the idea that they shall be used only in special cases, and a check valve is set against their mixture with the pure city supply. Theoretically this is all right, but if the check valves get out of order, as they have an unfortunate habit of doing, and bad water enters the city mains, causing an epidemic of typhoid fever, the past usefulness of the check valve is immediately and utterly discounted, for no commercial economy is measurable in terms of sickness and death.

Mr. Saville speaks of eternal vigilance as the price of success with check valves. That is true. Monthly or even daily inspection, however, will not make a check entirely reliable. It may get out of order a few minutes after inspection and between that time and the next inspection, when the defect is found, do untold and immeasurable harm. Naturally the insurance people try their level best to make them reliable in operation, and safe, but a single check or a double check is liable to err.

A generation ago the check valve was considered a mighty useful appliance, but then we knew little of the dangers in impure water. It was only thirty-five years ago that the typhoid germ was discovered. To-day, however, we know a lot of things about the typhoid germ and typhoid fever and its causation, and, furthermore, through experience, it may be said that we are pretty well "onto" the check valve and its idiosyncracies. Where a

* Consulting Engineer, New York.

city has a dual system of water supply, one coming from polluted sources, — for fire protection, — and separated from the pure supply only by a check valve, one must conclude that such a city is taking big chances, for if "to err is human," erring on the part of the check valve seems to be a prominent feature in its makeup.

Finally, in the interests of the public health, the fire insurance underwriters ought to be as willing to gamble on the promptness of a watchman in opening a gate valve on an auxiliary line in times of emergency, as on a check valve which fails to act properly at the right time, or which is a greater menace to health than fire. Incidentally it may be added that in the United States in the last thirty years the vital capital dissipated by typhoid fever was over three times the net property loss from fire, so in questions like this, offering a choice between the loss of life and the loss of property, there should be no hesitancy in lining up on the side of health. The check valve, separating an impure auxiliary water supply from a pure city supply, is decidedly on the other side.

MR. R. C. P. COGGESHALL.* In New Bedford we have a number of the check valves which Mr. Saville has spoken of; in fact, we may have more than in any other place in the United States. We have at least 120. They are all put in on the basis that Mr. Saville has outlined. They are frequently inspected and careful note is made of each inspection, and I would say that at the present time they are working admirably, but their success depends upon vigilance. It is almost a necessity for us to have these valves in our city, because we haven't any dual supply as other cities have. Moreover, if any of these check valves should fail we would know it at once, because we would get salt water and not fresh water. The mill people would know it mighty quick, because they would get the salt water right in their plants if a check should fail. But we are looking after them all the time, for we believe there is no other safe way to do, and under our inspection they are working admirably.

MR. WILLIAM R. CONARD.† A number of years ago, when the methods were more or less by rule of thumb among the founders,

* Superintendent of Water Works, New Bedford, Mass.
† Burlington, N. J.

the causes for rejecting pipe were one thing, and as time has passed and the founders have improved their methods and have, at considerable expense to themselves, installed more scientific methods of procedure, the conditions and causes for rejection have also changed, due to the varying conditions under which the pipe are made. The present pipe specifications provide only for physical characteristics, and there was a time when that was sufficient to obtain the desired results, for the reason that the founders at that time were using practically all pure pig-iron with their own foundry scrap. By the use of analytical methods of determining what the mixtures are, they have found that they can meet the physical requirements of the specifications and can use a certain per cent. of outside or purchased scrap. The purchasers of cast-iron pipe have received the benefit of that use of outside scrap in reduced prices. In fact, the methods were adopted to meet the high competition that has been extant for a number of years in the pipe manufacturing business. The use of outside scrap, unless it may be large machinery scrap, makes the actual chemical properties of the mix a rather unknown quantity, and it is a question whether, in the use of pipe specifications, or the formulating of specifications for cast-iron pipe, it will not be necessary in the future to adopt some average condition of chemical components and insert it in the specifications, and also, if possible, limit by specification the amount of outside scrap that can be used. That, I may say, is a phase of specifications which is being considered by your present committee on pipe specifications.

Mr. L. H. Kunhardt.* Mr. Chairman, I would like to say a word. Of course those of you who know how I am connected in the fire protection work appreciate that I do believe in the double check valve; and the reason for it is because, as has been said here, it seems to furnish the only solution of the problem that we all have of making the public water supply serve its use for fire protection in the best way, that is, by putting the water directly at the seat of the fire. I know of nothing that can be done better than to give the automatic sprinkler the very best supply that you can. Some may say that a certain amount of water, a thou-

* Vice-President Manufacturers Mutual Insurance Company, Boston.

sand gallons a minute, is enough. It probably is in perhaps ninety-nine cases out of a hundred, but we are all of us constantly dealing with larger values, more concentrated values, and once in a while we have a case where we need all the water we can get hold of, — and then we wish we had a little more. If the pressure drops on the sprinkler equipment at any time, the fire gets under way and it is likely to destroy the building. Whenever a valve is shut on the sprinkler system, the result is the same.

I think you will find that in almost every case where there has been trouble from a pollution of the public water supply it has been due to a condition which antedates the real serious consideration of this problem of the double supply. Every case of which I have known, where there has been any leak back into the main, has been due to the imperfect arrangement of the old-fashioned system, with perhaps a single check valve buried in the ground; and also due in part to the condition which used to obtain in many cities and towns years ago, where the factory or mill had the best pumping equipment there was in the town, perhaps the only reliable high-pressure supply, and perhaps pumping from the river. The town system had a small reservoir and small pipe put in in the days when the community was much smaller than it is to-day. Now they have a fire and the supply isn't adequate; the fire gets away from them, and they appreciate the streams which can be supplied by the mill pumps, and if those streams cannot be brought to bear from where the mill is situated, they will pump through the town mains. They have even gone so far as to ask the mill to arrange a by-pass around the check valves, so they can bring the water to the fire.

We approve the double check valve with a view of making as safe and as perfect an arrangement as can be designed; and then, in order to make it as secure as possible, we put them in pairs, so that if one should happen to leak a little, the other one will serve its purpose. And we have arranged them all in vaults, so they can be easily inspected and cared for. Mr. Coggeshall said they were working admirably, and Mr. Saville said that they seemed to furnish the best solution of the problem where it is necessary to have a double supply. Our experience with them has been eminently satisfactory. We have studied the problem from both

sides, and it seems to me that there is nothing better which at present can be offered to manufacturers and large mercantile establishments to afford the protection which they need all the time, and which is essential if the public water supply for any reason is cut down in pressure, or if it is shut off in the street where the fire occurs and where the sprinkler connection is taken.

MR. H. O. LACOUNT.* This paper is of particular interest to fire protection engineers, and there is one point in reference to check valves in which I am personally very much interested which was not touched upon by Mr. Kunhardt, and I do not think was referred to by Mr. Saville, and that is the great value of fire protection in industrial plants, not only for the large property values, but also for the human life. Now I should like to put on record here the statement that in the approximately three thousand mills, scattered all over this country, insured in the Mutual Companies, and which are largely under sprinkler protection, during thirty-five years only five lives have been lost by fire; and those factories are occupied every day by about a million and a half of people. That seems to me to phenomenal record, a very wonderful record, in a sense, and it is an incentive to every one having to do with the fire protection system to give it the very best possible water supply, in order that the good work may not be hindered, but may go on. So when one speaks of the matter of the health of the community in connection with the pollution of the city water supply, I think there are two sides to the question, and I think the maintaining of these two supplies for fire protection is also in the line of saving life.

By the way, as a further record, there are about one hundred and fifty of these connections now in the country, of which we have knowledge, equipped with these double checks. In other words, there are about three hundred single checks installed in pairs. And the record of those checks is still good, after six or seven years of experience. Mr. Saville, in his characteristically vigorous manner, has condemned the dual system, but he also is fair to the double check system in that where the dual system is, or for any reason is considered to be, the best solution of the necessities of the case, this double check does answer the purpose better than any other thing that has yet been put before us. Credit to whom credit is due.

*Engineer, Associated Factory Mutual Fire Insurance Companies, Somerville, Mass.

There is one other thing on which perhaps Mr. Saville thought that if I got the floor I would lock horns with him from the fire protection standpoint, and that is the throttling of gates. But I am not disposed to do that, but I simply want to put in this caution, — that when the necessity becomes apparently urgent we don't do it unless we know, not from paper figures, but from a demonstration and a test, that we haven't throttled them at any point so that we can't supply from fifty sprinklers, say, approximately one thousand gallons a minute without a serious loss of pressure, — in other words, without dropping the pressure to a non-useful point, so far as the sprinkler system is concerned.

THE MIDDLEBORO, MASS., REINFORCED CONCRETE WATER TOWER TANK.

BY GEORGE A. SAMPSON.*

[*Read December 8, 1915.*]

The town of Middleboro is situated in Plymouth County, Massachusetts, and like many other places in the southeastern part of the state, and elsewhere, has no favorable site for a storage reservoir or standpipe for a gravity fire supply. The highest point of land in Middleboro, or within fifteen miles roundabout, is Barden Hill, about 4 600 ft. southeast of the business center of the town, with an elevation of only 35 ft. above a considerable part of the residential district and about 175 ft. above sea-level.

This fact, together with the following brief description of the Middleboro Water Works, will aid in an understanding of the conditions which led up to the construction of the present concrete tower tank.

The works were built in 1885 by the Middleboro Fire District. The source of supply is a large dug well 26 ft. in diameter and 22 ft. deep, located about a mile southeast of the center of the town and 60 ft. from the east bank of the Nemasket River, and fed for the most part from the gravelly hills and tableland to the east. A brick pumping station was erected nearby, equipped with two Deane, compound, condensing, duplex pumping engines, each of 600 gal. per minute capacity, against a head of 200 ft., discharging through a 10-in. force main into the distribution system supplying the district. A wrought-iron standpipe 20 ft. in diameter by 103 ft. in total height, with a capacity of about 235 000 gals., was erected in a residential section of the town, the highest available location on the west side of the river, giving, when filled to overflowing, a static hydrant pressure at the business center of 63 lbs., often reduced to 56 lbs. or less under ordinary conditions of draft, and still further decreased by the friction

*Of Weston & Sampson, Consulting Engineers, Boston.

in the mains and hydrant. This pressure was sufficient for domestic uses but inadequate for fire protection, especially in view of the increased pressure standards generally recognized as desirable.

To relieve this condition, an electrically operated valve, controlled by a switch at the pumping station, was installed during 1908 in the pressure main at the base of the standpipe; and a relief valve was placed on the discharge from the pumps set to blow-off at about 115 lbs. at the station, which corresponds to a static pressure of 95 lbs. in the business section. Upon the sounding of a fire alarm, the electric valve was closed and direct pumping into the mains with both pumps depended upon for the requisite quantity of water and the desired pressure. At the same time, the capacity of the two pumps was increased, by boring out the pump cylinders, from 1 200 to 1 600 gals. per minute, which, with an allowance for ordinary domestic uses, furnished from four to six good fire streams.

Then came the eight-hour laws in Massachusetts which, in order to insure a ready-to-serve fire supply, necessitated the employment of six men at the pumping station, three of whom must be licensed engineers, — an expense out of all proportion to the size of the plant. Add to the above considerations the fact that the standpipe had been in service for thirty years; that a careful inspection in 1911 revealed an altogether too narrow margin of safety, and another in 1913 showed a still more urgent need of its immediate discontinuance, and you can imagine the conditions that recently confronted the water commissioners, of whom Mr. Alvin C. Howes, a member of this Association, is chairman and superintendent of the water works.

After several Fire District meetings and much discussion, it was voted, in February last, to construct on Barden Hill a standpipe of 500 000 gal. capacity, and the commissioners engaged the writer to design and supervise the construction of the proposed structure. The problem presented was the storing of half a million gallons of water at an elevation sufficient to meet the combined demands of domestic and fire services. The most economical type of structure fulfilling the requirements was a tower tank, an elevated tank supported on a tower, sometimes

called a water tower, and the only practicable materials for building such a structure were steel and reinforced concrete. A steel tower tank was estimated to cost about $2 000 less than one of concrete, but the cost and inconvenience of frequent painting inside and outside, a safe life of not over thirty years, its unsightly appearance, and other considerations made it apparent that if a satisfactorily watertight concrete tank could be constructed it was greatly to be preferred. The difficulties, however, of designing and building such a structure, especially of the proportions

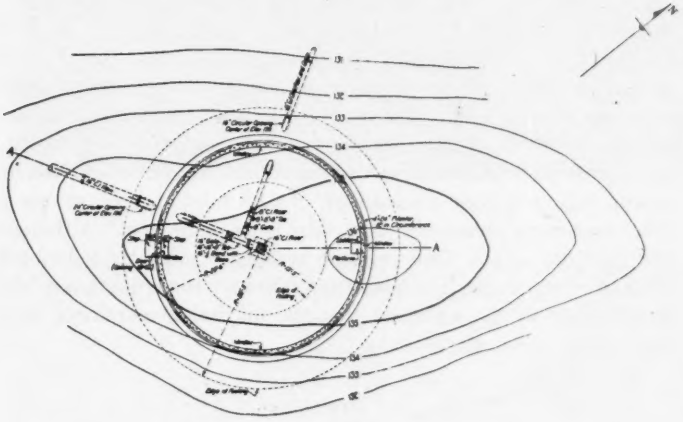


FIG. 1.

required, were many and vital. Its success or failure, perhaps more than in any other engineering work, depends to a large degree upon each individual connected with the work from the time the concrete materials are selected until they are finally deposited between the forms to become a monolith of artificial stone. With due regard for the difficulties involved, it was nevertheless decided in favor of a concrete structure.

Plans and specifications were prepared, and bids from seven contractors were opened on April 6. The lowest of these bidders was the Hennebique Construction Company of New York City, to whom the contract was awarded on April 12 for the sum of

$23 140. Mr. Thomas F. Dorsey was engaged by the writer as resident engineer in direct charge of the work.

Foundation.

The foundation extends 7 ft. below the finished grade and rests upon a fine, well-compacted sand, the safe bearing power of which was determined experimentally by loading a timber set at the elevation of the bottom of the foundation. At a loading of from 1 to 3½ tons per square foot, the settlement was uniform and slight, being only $\frac{1}{32}$ in. for each additional ½ ton; but 4 tons per square foot produced a relatively large settlement — $\frac{5}{32}$ in. for the last ½ ton. The footing area is such that with the total dead weight of 4 485 tons the soil is compressed to the extent of 2.28 tons per square foot. The wind load was computed from an assumed velocity of 70 miles per hour, the equivalent of 30 lbs. per square foot on a vertical projection of the structure, which with a full tank adds a maximum of 0.68 tons, thereby giving a total maximum pressure of 2.96 tons per square foot. Although the resultant of the wind pressure is slightly more than doubled with an empty tank, it is more than offset by the reduction in the dead weight of the water, so that the maximum mentioned represents the worst condition.

Tower.

A cylindrical tower was adopted in preference to a number of columns, because structurally it seemed a safer type of support, would probably be more economical to construct, and could be made to present a more pleasing appearance. Considerable study was given to the architectural side of the problem in order to produce at a moderate cost a structure that would be, to some extent at least, an addition to the landscape. The plain aspect of a simple cylinder is relieved by the addition of twelve 4- by 24-in. pilasters, which were assumed to take their proportion of the load. The appearance of solidity at the bottom is accomplished by a concrete seat extending around the base of the tower. A balcony of reinforced concrete with bracket supports, paneled posts and railing, the floor of which is 108 ft. above the ground, furnishes a

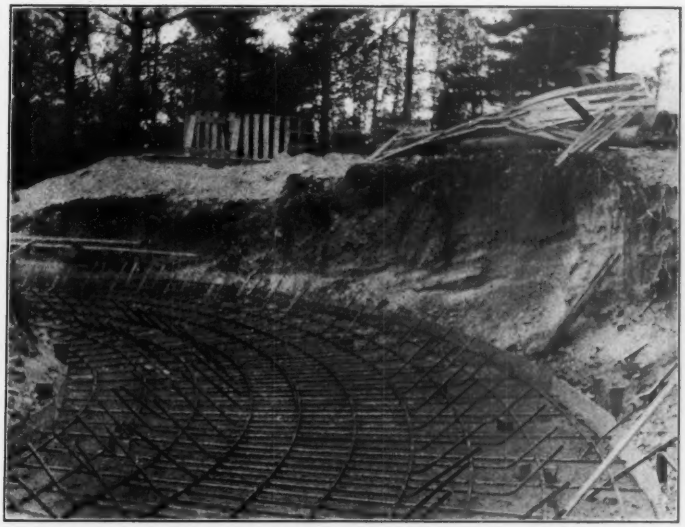


FIG. 1.

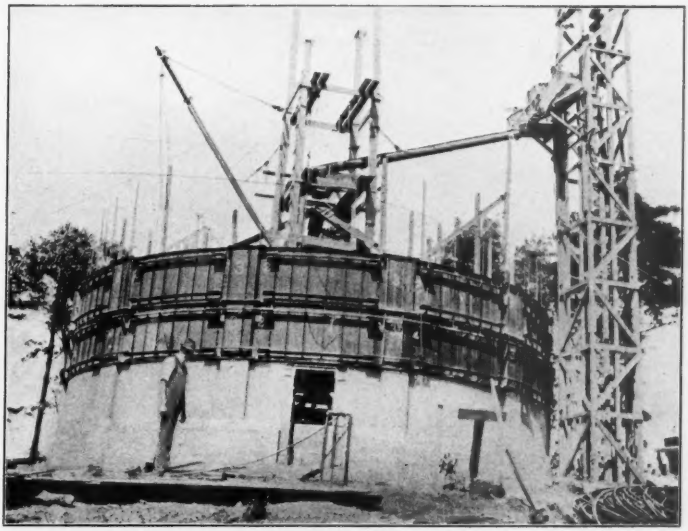
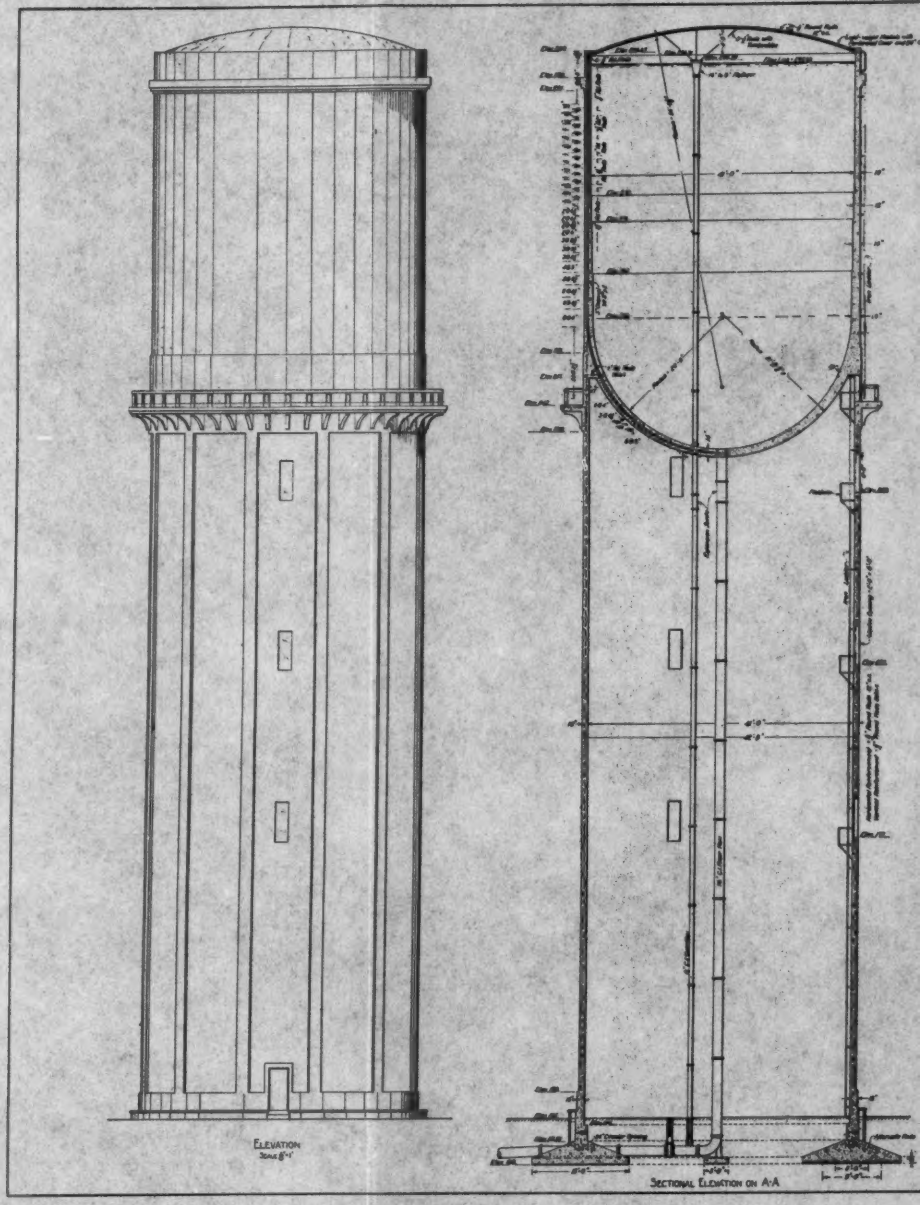
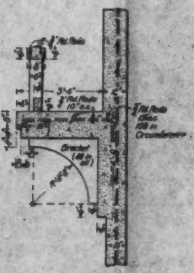


FIG. 2.

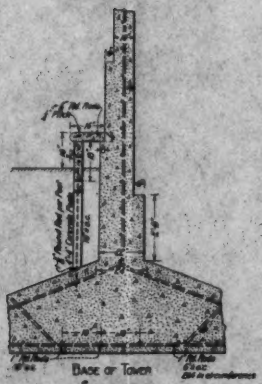

ELEVATION
SECTIONAL ELEVATION ON A-A

JUNCTION OF ROOF AND WALL.

BELTING COURSE.

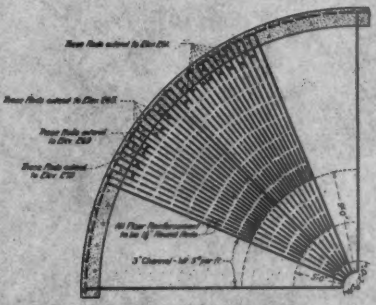


BALCONY

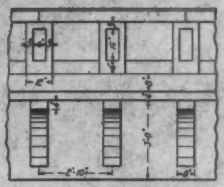


BASE OF TOWER

SECTIONS
SCALE 1"=1'



PLAN OF RADIAL REINFORCEMENT
IN BOTTOM OF TANK
SCALE 1/4"=1'



ELEVATION OF BALCONY
DEVELOPED ON 21'-8" RADIUS
SCALE 1/4"=1'

MIDDLEBOROUGH WATER WORKS
MIDDLEBOROUGH, MASS

CONCRETE TOWER TANK

SCALES AS NOTED
March 22, 1915

Commissioners

George A. Hampson
Civil Engineer
44 Beacon St.
Boston Mass

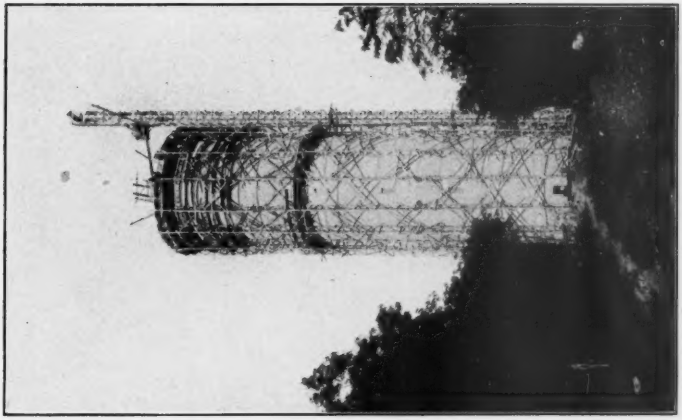


FIG. 2.

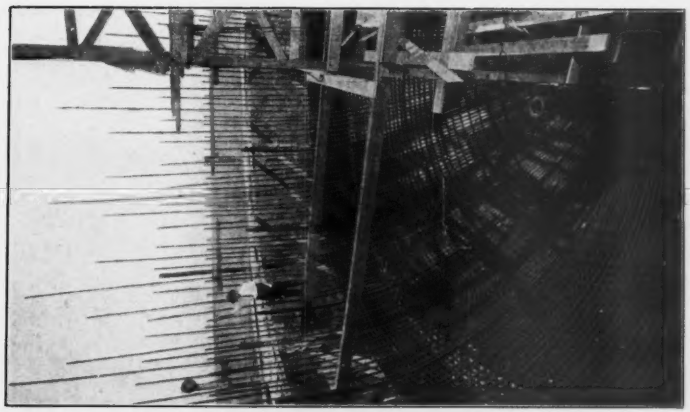


FIG. 1.

suitable point of vantage for inspecting the outside of the tank, and provides a visual starting point for the tank proper. The thickness of the tower wall between pilasters is 10 ins. and the greatest compression due to the dead load is 483 lbs. per square inch, increased to 631 lbs. by a 70-mile gale. Entrance to the tower is through an iron door. Light and ventilation are provided for by means of twelve windows, three of which are arranged to open. An iron ladder within the tower leads from the ground to the balcony through an opening in the wall of the tower at the elevation of the balcony floor. Another iron ladder on the outside of the tank connects the balcony with the roof above. A 16-in. cast-iron flanged pipe with expansion joint rises from the ground and enters the tank at its center. An 8-in. overflow and drain discharges at a safe distance from the tower.

Tank.

The tank proper, 41 ft. in inside diameter and having a depth of water at its center of 59 ft., has a capacity of slightly over half a million gallons. The bottom of the tank is a hemispherical bowl hung at its rim from the wall of the tower, and marks the first application of this type of bottom to an elevated concrete tank, although for many years it has been used with success in elevated steel tanks. The bowl itself has a capacity of 125 000 gals. The vertical wall of the tank varies in thickness from 10 ins. at the top to 16 ins. at the bottom, and the hemispherical bowl from 18 ins. at its connection with the tank wall to 14 ins. at its center. The thickness of concrete is such that without any assistance from the steel reinforcement its stress in tension is about 250 lbs. per square inch. The tensile stress in the steel acting independently is approximately 14 000 lbs. per square inch; and with both materials acting in conjunction the computed stresses are 215 and 2 150 lbs. The tank is covered to guard against the growth of algæ, not uncommon in a filtered water supply exposed to light, and to prevent freezing. The roof is a concrete dome 4 ins. thick, 41 ft. in diameter, and with a rise of 4 ft. at the center. The thrust is carried by steel reinforcement embedded in the top of the tank wall.

Concrete.

Whitehall cement from the Whitehall Portland Cement Company's mill at Cementon, Pa., was used throughout the work. Sampling and testing was done by the New England Bureau of Tests, of Boston, samples being taken as loaded on the cars, which were then sealed. The tests of the twelve carloads required, aggregating 8 100 bags, were unusually uniform and satisfactory, especially for the essential qualities of strength, fineness of grinding, and slow initial set. The sand and coarse aggregate were obtained from a gravel pit about $1\frac{1}{4}$ miles distant, screened by hand at the pit to give the sizes required. The sand was tested for tensile strength as compared with standard Ottawa sand and gave an average of $112\frac{1}{2}$ per cent. thereof. The gravel stones were washed to remove a slight coating of clay and cemented sand. The proportions of the concrete for the foundation are 1 of cement, $2\frac{1}{2}$ of sand, and 5 of gravel stone; for the tower, 1 : 2 : 4; for the hemispherical bottom and wall of the tank to elevation 279, 1 : 1 : 2; from elevation 279 to 293, 1 : $1\frac{1}{2}$: 3; and above elevation 293, including the dome roof, 1 : 2 : 4. The relative amounts of sand and stone were somewhat varied to provide the densest practical mix, the percentage of cement to the sum of the aggregates, however, remaining as stated. The amount of concrete used in the work was 1 120 cu. yds.

Steel Reinforcement.

"Havemeyer," round, deformed, open hearth, hard grade reinforcing rods furnished by the Concrete Steel Company of New York, and bent at the rolling mills, were used in the structure. These were tested at the Carnegie mills by the New England Bureau of Tests, a large proportion of which were $1\frac{1}{4}$-in. and developed an ultimate tensile strength of 120 000 lbs. per rod. Laps were 40 diameters, and in addition each joint in the tank was secured by two cable clips. The horizontal rods of the tank were firmly secured in their true position to sixteen vertical 3-in. channels drilled to the exact spacing of the rods. One hundred and sixty thousand pounds of steel reinforcement were embedded in the concrete.

Forms.

Steel forms made by the Blaw Steel Construction Company of New York were used for the outside surface of the tower and tank. Two complete rings were provided, each 4 ft. in height, at a total cost of $600. Two 4-ft. rings of wooden forms were used on the inside at a first cost of $400. The use of steel forms was justified both on account of a considerable saving in time and expense in erection and because of the resulting smooth, dense surface, requiring very little finishing and less susceptible to the action of the elements. The hemispherical bottom was cast between forms consisting of wooden ribs covered with sheet iron.

Joint between Old and New Concrete.

For the tower, in order to secure a bond between the successive rings of concrete, the forms were overfilled about $\frac{1}{4}$ in., which surplus containing the laitance was screeded off previous to the initial set of the concrete, following which as soon as the final set occurred the surface was wire-brushed to slightly expose the stones and, immediately before placing fresh concrete, washed with a hose stream and coated with a neat cement grout. For the tank, in addition to the above precautions which were carried out with especial care, there was cast in the old concrete a continuous triangular groove, about $1\frac{1}{2}$ in. in depth, running around the wall near its center and subsequently filled with grout and concrete; to still further minimize the chances of leakage, at each horizontal joint an uncoated steel plate or dam of No. 14 gage metal 10 ins. wide, turned over one inch at each edge to form a channel, and bolted together to form a continuous watertight stop, was embedded 4 ins. into the old work, thus leaving 4 ins. extending up for a bond with the new concrete. The cost of twelve channel rings in place was about $400.

Progress of Work.

Ground for the foundation was broken on April 26. After the excavation was completed the earth was wetted and thoroughly compacted by rammers, following which a 2-in. layer of concrete was placed over the entire surface to serve as a working base for

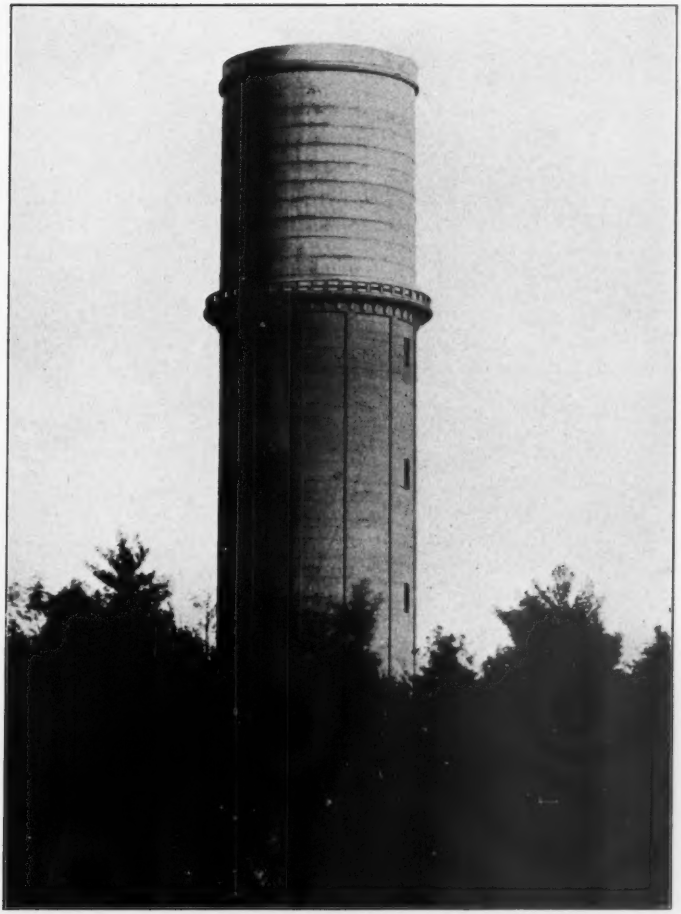
the erection of the steel reinforcement and as a suitable medium upon which to place concrete. All concrete was mixed in a 15 cu. ft. Smith mixer operated by steam and discharging into a bucket elevator which at the desired height was tripped and dumped into a receiving hopper, whence it was conveyed by gravity through a sheet steel chute to a central distributing hopper, and finally by means of eight movable wooden chutes was deposited between the forms around the circumference.

The concrete materials were brought to the mixer in dump cars running on an inclined industrial railway and pulled up the incline by a cable attached to a drum of the hoisting engine. The average rate of progress on the tower was a 4-ft. ring each alternate day, with a marked increase in efficiency as the work advanced. The actual time required for concreting was about four hours to each 4-ft. section. The bottom of the tank, including four feet of the wall immediately above the tower, was poured continuously. Concreting began at 5 A.M. on September 9, and the last batch was deposited at 4 A.M. the following day, during which time about 130 cu. yds. of 1 : 1 : 2 concrete were placed. Five days elapsed before the following section was in place and two more days before the succeeding ring was concreted. Four days were then spent in preparing for future operations, so that when concreting began again on the fifth day the following eight successive lifts were made in nine days, and it was only due to a violent gale of about seventy miles per hour that operations had to be suspended for one day. The roof of the tank was poured on October 13.

WATERTIGHTNESS.

As soon as the forms were removed from the inside of the tank and the staging from around the outside, the surfaces were cleaned and so far have received no further treatment, although after the tank has been fully tested and accepted as satisfactorily watertight, the question of waterproofing the inside and damp-proofing the outside surface will be considered. Coincident with the removal of the outside staging around the tower, the surface was cleaned and washed with a brush coat of neat cement grout, mixed in the proportion of one of cement to one of water. The

PLATE XII.
N. E. W. W. ASSOCIATION.
VOL. XXX.
SAMPSON ON
MIDDLEBORO WATER TOWER TANK.



cost of cleaning and coating the 14 000 sq. ft. of surface was $75.00, or about 0.54 cent per square foot. In connection with the subject of watertightness, the following clause from the specifications may be of interest:

"The concrete in the bottom and wall of the tank shall be substantially watertight at all times. Any leakage amounting to jets or visible seepage shall be repaired by and at the expense of the contractor and by methods approved by the engineer. Small damp spots, if few in number, which do not increase nor disfigure the appearance of the concrete, will be considered to meet the requirements hereunder. It is intended that the work shall be sufficiently waterproof that severe freezing will not at any future time threaten the integrity of the concrete and that the general appearance of the structure will not suffer through efflorescence or other disfiguring stains."

The work, including grading and cleaning up, will be completed this week, and it is hoped that water may be turned into the mains to supply the District on January 1. The static hydrant pressure with a full tank will be 84 lbs. in the higher residential area, 104 lbs. in the business center, and 120 lbs. in the low district along the Nemasket River, reduced by about 20 lbs. by frictional losses during an ordinary fire. For the year 1914 the population supplied with water was 5 000 and the average daily consumption 320 000 gals., so that a thirty-six hours' supply of water is available, every drop of which is of value.

REVENUE AND OPERATING EXPENSE OF MUNICIPALLY OWNED WATER-WORKS IN MASSACHUSETTS FOR THE YEAR 1913.

BY CHARLES W. SHERMAN.*

There has recently appeared from the State Bureau of Statistics the Eighth Annual Report on the Statistics of Municipal Finances covering the year 1913 (that is, fiscal years ending between November 30, 1913, and April 1, 1914). This report contains in considerable detail the figures indicating the financial transactions of all the cities and towns in the Commonwealth. Those for water-works systems are not grouped by themselves but are given in the general tabulations under the heading "Public Service Enterprises." The gross amounts contained in these tables are of little significance in themselves and cannot readily be compared with those of other cities and towns, except those appearing on the adjoining pages of the report.

In order to obtain really significant data from these figures, the writer has abstracted the figures of revenue and operating expense for all the cities and towns having municipal water works and has computed the per capita revenue and expenses, using population estimated on the basis of the 1910 and 1915 census figures. The results are given in the three tables accompanying, where Table 1 contains the statistics of the thirty-six cities; Table 2, those of the fifty-two towns having a population of 5 000 or over; and Table 3, those of the forty-seven towns having a population of less than 5 000.

It should be noted that in substantially if not absolutely all cases, the figures reported are based on cash receipts and expenditures and not necessarily on the true earnings and expenses for the year under consideration. It is also to be remembered in comparing these figures with similar figures for privately owned water-

NOTE. — This paper has not been read at any meeting. Discussion is invited for future publication.

* Of Metcalf & Eddy, Consulting Engineers, Boston.

works systems that in but few of the municipally owned plants does the water works receive any revenue for fire protection or hydrant service, and that in no case except Holyoke does the water department pay taxes. It must also be borne in mind that in a very large number of cases, particularly in the small towns, the administrative machinery of the town is utilized for the benefit of the water works without compensation out of water revenue, — thus town treasurers or collectors of taxes in a great many cases render and collect the bills for water, the office and possibly the shop of the water department is in the town hall, and it may be in some cases that one of the selectmen or some other town officer acts as superintendent without additional compensation, or, at most, with very slight compensation from the water department.

Tables 1 and 2, relating to the cities and the larger towns, represent long-established water-works systems in which the development is substantially complete. That is to say, the water pipes reach substantially all parts of the communities and the number of people not supplied from the public works is insignificant. In the case of the smaller towns listed in Table 3, however, the conditions are very different in many cases. Oftentimes these works supply only the thickly settled central portion of the town, while a considerable portion of the population living in outlying districts is not reached by the water works. In such cases per capita figures, based on the entire population, are obviously of comparatively slight significance and should be used with great caution. In other cases the works have been recently established and have not yet reached their full development, even in the districts supplied. In a few cases of summer resort communities the revenue and expenses are abnormally large for the permanent population and ought more properly to be based on the maximum or transient population, if trustworthy figures were available.

In the case of cities and towns in the Metropolitan Water District, it should be noted that the operating expense includes only so much of the Metropolitan assessment as relates to maintenance of the Metropolitan Water Works.

For the reasons set forth above, the averages for Table 3 are probably not of great significance. Those of Tables 1 and 2 are, however, probably fair indications of the per capita revenue and

operating expenses to be expected of thoroughly developed municipal water works in this state. Local conditions, of course, have a very considerable effect, particularly upon the operating expense; and the extent to which funded debts have been retired and the amount of extensions to be paid for out of earnings in addition to meeting operating expense would largely affect the amount which should be assessed in gross revenue.

It is hoped that water commissioners and superintendents will find these figures of assistance, particularly in making it possible to compare the conditions in the works under their charge with those of other cities and towns where the conditions are more or less similar.

DISCUSSION.

MR. CHARLES F. GETTEMY.* I am sure I voice the sentiments of my assistant, Mr. Waddell, who is here with me this afternoon, as well as my own, in expressing to you, Mr. President, and to Mr. Sherman, who is responsible, I presume, for our presence here, our great appreciation of the opportunity which you have given us to get away from our desks and some of our routine duties in order to come here and meet this intelligent body of scientific men. It is a great privilege to be able to come in contact with such a body and have the opportunity to listen to these interesting papers that have been read.

The hour is so late that it does not seem to me that this is perhaps the time to say anything that might lead to an extensive discussion of the very important matter which has been raised by Mr. Sherman in his interesting and certainly suggestive paper. It is, nevertheless, an exceedingly important point that has been raised as to whether our present municipal indebtedness laws should be amended along the lines suggested, and I hope you will believe me when I say that we have absolutely no pride of opinion in regard to these matters, and that we are only anxious to see the municipal indebtedness laws of Massachusetts in such form as will make for sound management of municipal finances, as well as drawn in such a way as not seriously to affect the convenience and well-being and health of the people who compose our municipalities.

* Director State Bureau of Statistics, Boston.

TABLE 1.

GROSS WATER-WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS CITIES FOR THE YEAR 1913.

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
1	Boston	721 700	$4.08	$1.43
2	Worcester	156 012	2.86	0.60
3	Fall River	122 592	1.86	0.63
4	Lowell	107 405	1.82	1.31
5	Cambridge	107 230	3.57	1.12
6	New Bedford	104 400	2.66	0.81
7	Springfield	97 353	3.69	2.01
8	Lynn	93 215	3.34	1.64
9	Lawrence	88 511	1.53	0.71
10	Somerville	83 000	2.79	0.73
11	Brockton	60 124	2.45	0.91
12	Holyoke	59 580	2.16	1.66
13	Haverhill	47 316	2.72	0.85
14	Malden	46 500	2.27	0.73
15	Newton	41 789	3.42	0.96
16	Salem	39 800	3.05	1.27
17	Chelsea	39 037	3.20	0.67
18	Fitchburg	38 922	2.15	1.28
19	Quincy	37 460	3.26	0.68
20	Pittsfield	36 612	3.24	0.57
21	Everett	36 025	3.15	0.78
22	Taunton	35 399	2.67	1.26
23	Waltham	29 226	3.15	1.53
24	Chicopee	28 242	2.35	0.97
25	Medford	27 566	2.45	0.52
26	Gloucester	24 446	4.45	1.21
27	Revere	23 289	3.16	0.79
28	North Adams	22 028	2.79	0.41
29	Beverly	21 236	3.36	1.66
30	Northampton	20 766	2.95	0.96
31	Leominster	17 619	3.50	0.68
32	Attleboro	17 574	3.84	1.05
33	Melrose	16 411	2.72	1.13
34	Woburn	15 968	3.29	1.12
35	Newburyport	15 165	4.10	1.41
36	Marlborough	14 981	3.03	0.77
Average		69 290	3.16	1.14
Maximum			4.10	1.66
Minimum			1.53	0.41

Ratio of average operating expense to gross revenue = 36 per cent.

TABLE 2.

GROSS WATER-WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS TOWNS OVER 5 000 POPULATION FOR THE YEAR 1913.

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
1	Brookline	31 312	$3.47	$1.40
2	Peabody	17 464	5.60	1.59
3	Westfield	17 463	2.76	0.50
4	Gardner	15 704	3.97	1.14
5	Watertown	15 059	4.02	0.60
6	Framingham	14 694	4.52	1.31
7	Weymouth	13 540	3.66	0.85
8	Arlington	13 407	4.37	1.48
9	Clinton	13 144	2.58	0.80
10	Methuen	12 984	2.35	0.82
11	Plymouth	12 612	2.92	1.02
12	Wakefield	12 229	3.17	1.53
13	Webster	12 142	1.92	0.70
14	Winthrop	11 707	4.88	1.95
15	Natick	10 619	2.61	1.30
16	West Springfield	10 493	4.70	1.94
17	Danvers	10 469	3.69	0.94
18	Winchester	9 726	4.00	2.28
19	North Attleboro	9 463	2.94	1.28
20	Saugus	9 355	1.49	0.78
21	Easthampton	9 316	1.92	1.08
22	Athol	9 283	4.35	0.95
23	Norwood	9 193	3.63	1.36
24	Ware	9 116	1.33	0.97
25	Amesbury	9 084	3.75	1.05
26	Braintree	8 831	4.34	1.94
27	Milton	8 329	6.08	2.66
28	Andover	7 706	2.96	1.13
29	Marblehead	7 500	4.41	1.59
30	Whitman	7 430	2.54	1.39
31	Stoneham	7 330	3.20	1.29
32	Belmont	7 282	3.55	0.82
33	Rockland	7 015	2.94	1.91
34	Swampscott	6 888	5.90	2.31
35	Hudson	6 752	2.26	0.29
36	Stoughton	6 715	2.31	0.86
37	Maynard	6 618	2.04	0.68
38	Concord	6 577	4.45	1.54
39	Reading	6 409	3.78	1.55
40	Spencer	6 293	1.86	0.30

TABLE 2. — *Continued.*

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
41	Franklin	6 121	$2.95	$0.90
42	Ipswich	6 074	2.45	0.82
43	Wellesley	6 028	4.94	1.80
44	Needham	5 935	2.89	1.29
45	Winchendon	5 816	2.53	0.89
46	North Andover	5 784	2.07	1.12
47	Westboro	5 734	1.94	0.74
48	Abington	5 569	3.18	1.57
49	Orange	5 340	2.69	0.93
50	Canton	5 292	2.94	1.85
51	Lexington	5 290	5.00	1.26
52	Walpole	5 252	3.93	2.15
Average		9 529	3.43	1.24
Maximum			6.08	2.66
Minimum			1.33	0.29

Ratio of average operating expense to gross revenue = 36 per cent.

TABLE 3.

GROSS WATER-WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS TOWNS UNDER 5 000 POPULATION FOR THE YEAR 1913.

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
1	Monson	4 905	$1.40	$0.32
2	Uxbridge	4 821	2.77	1.24
3	Randolph	4 562	2.38	1.09
4	Dudley	4 330	2.07	0.72
5	Provincetown	4 324	2.25	1.12
6	Rockport	4 295	3.85	2.39
7	Agawam	4 134	0.58	0.36
8	Templeton	3 951	1.72	1.33
9	Falmouth	3 609	7.66	2.73
10	East Bridgewater	3 558	1.40	0.48
11	Barre	3 269	1.18	0.24
12	Billerica	3 062	2.47	1.56
13	North Brookfield	2 997	2.52	1.36
14	Holbrook	2 894	3.52	1.48
15	Pepperell	2 884	3.20	1.24
16	Manchester	2 835	6.47	4.70
17	Ayer	2 789	3.18	1.28

TABLE 3. — *Continued.*

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
18	Medway	2 786	$2.45	$0.69
19	West Bridgewater	2 537	3.24	0.69
20	Lancaster	2 536	3.72	2.55
21	Kingston	2 526	2.45	0.96
22	Hopkinton	2 467	1.38	1.19
23	Sharon	2 406	3.96	1.36
24	Hatfield	2 387	1.92	0.17
25	Holden	2 366	1.90	0.08
26	Douglas	2 167	1.02	0.74
27	Wrentham	2 145	2.46	1.04
28	Merrimac	2 142	2.55	1.51
29	Williamsburg	2 123	1.52	0.48
30	Brookfield	2 117	1.10	0.60
31	Avon	2 103	2.33	1.43
32	Wayland	2 101	1.40	0.78
33	Ashburnham	2 077	1.70	1.65
34	Ashland	1 877	2.50	1.19
35	Rutland	1 833	2.19	1.11
36	Northboro	1 764	2.86	0.70
37	Longmeadow	1 504	3.05	2.04
38	Marion	1 475	5.66	3.35
39	Millis	1 426	2.36	1.27
40	Plainville	1 400	1.65	1.22
41	Bedford	1 312	2.70	0.92
42	Nahant	1 307	8.85	4.40
43	Mattapoisett	1 305	1.68	1.30
44	Tisbury	1 274	10.40	5.70
45	Lincoln	1 256	9.72	3.60
46	Littleton	1 229	2.50	1.32
47	Russell	1 049	1.38	1.52
Average		2 556	2.80	1.34
Maximum			10.40	5.70
Minimum			0.58	0.08

Ratio of average operating expense to gross revenue = 48 per cent.

I am frank to say, however, that the matter is, in my opinion, of sufficient importance to warrant the legislature in giving very careful consideration to the question as to whether these laws should be amended. This particular proposition is so bound up with the whole subject of municipal indebtedness that I confess

it is difficult for us to divorce and isolate altogether water debt from other municipal debt; and, if you will allow me, I should like simply to content myself on this occasion with merely throwing out a few suggestions which possibly may throw a little light on the present legislation and the laws relating to the subject.

I think I am justified in saying that if, as has been suggested, the extension of the construction of water-works systems has been seriously interrupted in the last two or three years by virtue of the existence of this legislation which has been referred to on the statute book, resulting in a decrease in the amount of water-works construction and a discouragement of extensions, and a slowing down of the rate of progress at which such extensions were being made prior to the passage of this legislation, it has been due not so much to the fact that this is new legislation which has supplanted old legislation, but to the fact that for the first time laws which are from thirty to forty years old, as matter of fact, are now being more generally observed and enforced; and that if a greater rate of progress was being made formerly, it was not because that sort of thing was permitted under the laws as they stood prior to 1913, but because those laws were not enforced, and, if not directly evaded by our municipalities, were, at any rate, subjected to most elastic and loose interpretation. One, of course, always trenches on delicate and dangerous ground when he undertakes to say a given statute is being violated. That in the last analysis, of course, is a matter for the courts to determine. So, possibly, I had better say that the laws prior to the passage of the general municipal indebtedness act of 1913 regarding the amortization of municipal indebtedness by the serial method, so-called, were so loosely drawn that there was opportunity for a difference of opinion with regard to their construction. It may, therefore, be useful to the members of your organization, in the event that you think that an amendment of the present legislation ought to be sought, if I take up your time just for a few moments in giving you an outline of the facts that led up to the passage of this legislation.

It dates back to the preliminary investigation made by the Bureau of Statistics during the winter of 1911, when a bill was introduced into the legislature for refunding a demand note of one

of our towns that had been outstanding then about thirty-five years; and it appeared that although that note was bearing six per cent. interest, having been issued in 1875, the town was continuing to pay this rate of interest and would have done so indefinitely; and although it might be regarded as a pretty good permanent investment, it so happened that it was held by a board of trustees which for some reason wanted to turn it over, and when they walked into the town treasurer's office with the note and demanded the money, of course the town treasurer didn't have it and so the town had to come to the legislature and ask to have the debt refunded. That opened the eyes of a certain member of the Senate, who was curious enough to wish to ascertain to what extent our cities and towns had debts of that sort. So he introduced an order in the Senate asking the Director of the Bureau of Statistics to cause an inquiry to be made, — and incidentally requiring the report to be made in two weeks; sometimes when they get started on Beacon Hill they want to hurry things up pretty fast, — and to report the amount of outstanding indebtedness in our cities and towns for the payment of which no provision had been made.

We did the best we could with such data as we had on file in our office and made a report; and it disclosed such a condition of affairs that I am frank to say that those of us who felt some responsibility in regard to the matter were fearful that the legislature would be so influenced by that report that it might result in the passage of prematurely digested legislation. We wished to avoid that, and we frankly confessed that we had merely skimmed the surface of the subject and requested an opportunity to make a more thorough investigation, which request the legislature granted and authorized the department to make a complete investigation of the whole subject of municipal indebtedness in Massachusetts. They placed sufficient funds at my disposal to do that, and I sent agents into every city and town, and the following year was able to make the first complete presentation of facts in regard to the municipal debts of the Commonwealth which had ever been made. The order calling for the investigation incidentally provided that such recommendations for legislation as might seem desirable should be made.

We found in the course of the investigation that the Municipal Indebtedness Act, which had been placed on the statute books first in 1875, — up to that time there was absolutely no legislation, so far as we could find, governing this subject at all, — in the lapse of thirty-five years had very largely become a dead letter. The number of ways which our municipalities had devised to evade its provisions were extremely ingenious, and we found that some towns were issuing bonds or long-term notes for all sorts of things, such as the purchase of a town hearse in one small town; in another case, to publish a town history; and the other instances where debt was created for purely current expenses, such as the payment of school teachers' salaries and so forth, are too numerous to mention. There wasn't any doubt but that under the old law the incurrence of debt for current expenses was permissible for a period of ten years, — that is, permissible in the sense that it was legal, — and that was one of the great problems that confronted us in trying to draw a law which would put a stop to that practice.

The result was that we took the law as it stood on the statute books and revamped it and provided twe've or fifteen specific objects for which municipalities could borrow money. As no one could be found who could define the term " current expenses," it would be absolutely useless simply to pass a law prohibiting the creating of a debt for current expenses. The only way that problem could be met was by selecting those purposes which every one agreed would be proper objects for incurring municipal debt and authorize the borrowing for those purposes and then absolutely prohibit the borrowing for any other purpose.

The periods for which the loans should run were fixed so as to agree with the life of the object for which the loans were to be secured. As far as water districts are concerned, I don't think any change was made in the statute.

Regarding the method of amortizing debt, under the old statute the cities and towns were allowed the option of establishing sinking funds. In the original Municipal Indebtedness Act of 1875 sinking funds were the only method recognized; the serial method at that time was hardly known. In 1882 the legislature passed what was called the Serial Loan Act, which gave municipalities the option of issuing their debt by the serial method; and in the

course of time that has become more and more popular and finally reached the point where it is so generally recognized as the proper method of paying off debt that one very important provision of this new act was a clause which absolutely prohibited the further establishment of sinking funds by municipalities and required that payment be made by the serial method.

The serial method of paying the debt had been provided for in the old statute, but it was very loosely worded and it apparently didn't mean anything to our municipalities, especially to the towns, because they fixed their own interpretation upon it; and we found that a very popular method of interpreting the law was to provide that very small payments should be made at the beginning of the term and should gradually increase, postponing the burden to the next generation; and we found evidences of what we called, for lack of a better term, " ragged " serials. They would start to pay a portion next year and another portion the following year, and then they would skip from one to five years before they would begin to pay again. And so it became necessary to define with some exactness the term " serial," and that is the only respect in which the new statute can be said to supplant the old with reference to this matter. The new law merely defined the meaning of the word " serial ' without in any other way, I think, really affecting the original statute.

At the time that we made our report to the legislature we were confronted with the fact that no matter how long a list of specified purposes was inserted in the act as objects for which cities and towns could borrow, there would necessarily arise from time to time cases in numerous municipalities where they would want to borrow money for some specific purpose which every one might agree was perfectly legitimate in that particular case, and yet which it would be extremely dangerous to incorporate in a general law, because it would be taken undue advantage of. I think you gentlemen can all appreciate the point of that argument. How to provide for these cases was considerable of a problem. And in making my recommendations and in the first draft of the bill, a state board to pass upon that subject was provided for; but the committee to which this report was referred looked askance on that proposition and felt it would be taking away from the legislature

certain of its traditional functions, and that it would be very difficult indeed to get such a proposition through the legislature. In fact, I think the committee itself was very strongly opposed to it, and it was, therefore, decided to pass this general act and leave it to the municipalities that could not borrow in cases of emergency under the general act to take them before the legislature and ask for special legislation.

As I have said, we had these two investigations: First, a preliminary and rather superficial investigation, — that is, while it was thorough enough as far as it went, it didn't take in all aspects of the subject and was necessarily made in a short space of time; and then a more comprehensive investigation, which I think was generally regarded as a very thorough going over of the subject. We took our time for it, we spent nearly a year on it, and made our report to the legislature. In the meantime I was asked to make a special report on the subject of sinking funds and serial bonds, which resulted in the incorporation of the prohibitory clause as regards sinking funds to which I have referred. So that the Bureau of Statistics made three investigations of this subject.

The report came in in the latter part of the session of 1912, too late for considerate action by the legislature that year, and they thought the matter was of sufficient importance to justify the appointment of a special recess committee, and such a committee was appointed. Our report was entirely a statistical report, based upon an examination of the local accounts and statistics of debt, which we classified as well as could be done under the circumstances. The legislative committee approached the problem from an entirely different angle. They took this report as a basis of inquiry and then summoned before them the mayors of the thirty-three cities of the Commonwealth and the tax collectors and the assessors and the treasurers and the auditors of the cities, and the same officials of about seventy-eight towns, — they couldn't go over the whole list of three hundred and twenty towns, — and these towns were selected as to size and geographical location, and the committee, I believe, even traveled in the western part of the state, so that they got a pretty good line on the situation from the standpoint of the local officials, and their report was of peculiar value from that point of view. They made their

report to the Legislature of 1913, and that legislature appointed a special committee to which this special report and bill were referred, and the local officials throughout the state were again notified.

The committee did not satisfy itself with the usual somewhat perfunctory advertising of the hearings in the newspapers, but the officials throughout the state, the local officials, were notified and furnished with a draft of the bill and advised that if they had anything to say about it, the committee would be very glad to hear them. The point I am trying to make in this connection is that this legislation was the result of three distinct investigations by the Bureau of Statistics, scientifically made, and subjected to subsequent inquiry and going over of the subject by two legislative committees, — one of which sat almost continuously on the job, with hearings day after day for three or four months during the autumn of 1912, — and the regular standing committee of the legislature; so that this legislation really ran the gauntlet of, you might say, five investigations and inquiries; and I think I am entirely within the facts when I express the opinion that no piece of legislation ever put on the statute books of the Commonwealth was more thoroughly predigested, if I may use that term, than this general Municipal Indebtedness Law.

I think that Mr. Sherman, in the remark that he interpolated in his paper, in a measure hinted at a very important matter that should be taken into consideration, as to whether the liability to abuse in the letting down of the bars in this matter may not perchance be greater than the conceivable benefits in a few cases; and that is obviously something that we will all agree should be given very careful consideration, and which no doubt will be given careful consideration, by the legislative committee when this matter comes before them.

I think that is all I care to say by way of general statement. If Mr. Waddell has anything specific which he would like to offer, and you would like to hear him, I am very sure he would be glad to speak to you. Mr. Waddell, I may say, is the Chief of the Municipal Division of the Bureau of Statistics, which as a department, as you doubtless know, covers a wide range of statistical inquiry, and is organized into several divisions, and Mr. Waddell

is my assistant and adviser at the head of this particular branch of the work.

MR. T. N. WADDELL.* Mr. President, it is needless to say that I am very much interested in this particular legislation, since during the past three years the greater portion of my time has been devoted to working out problems of financing cities and towns. I would like to explain why the section mentioned in the paper, which permitted the borrowing for five years only for the extension of water mains, was enacted. It was for this reason: We were unable to convince the committee that the general law that permitted cities and towns to borrow for certain purposes should be extended and that municipalities should be permitted to borrow for water purposes under the ten per cent. limitation clause. The proposition was how to eliminate any borrowing whatever through general law other than for the establishment of new plants. It was shown that in many cities and towns new sections were being developed, and it was only fair that some borrowing be permitted for such development. It had been the practice, I am sorry to say, to make these borrowings for extensions for thirty years, notwithstanding the fact that they were annually recurring charges; and from the paper I take it that Mr. Sherman does not approve of borrowing for those purposes at all. Yet it seemed to us that permitting borrowing for five years, which would take care of the development of certain sections of a town, would permit of only slight abuse should you consider the town as borrowing for five years for annually recurring expenses.

The section as to districts was brought to our attention in a very forcible manner. As the certification of town and district notes goes through our office, it was our duty to determine whether or not (in our opinion) they were perfectly legal; and having before us certain district loans, the question was raised, On what authority are these to be issued? The fact is that there was no authority under general law for a district to borrow money, and I will not hazard a guess as to the amount of illegal loans outstanding to-day on account of districts. It is capable of demonstration that there are some, because we have drawn two bills to validate loans that we positively knew were outstanding. Last

* Chief of Municipal Division, State Bureau of Statistics.

year we undertook to draw a bill for refunding a certain indebtedness which had been outstanding for twenty-nine years, without a single solitary cent set aside for the payment of the debt. It seemed to us that with the ever-increasing indebtedness, some step must be taken to at least reduce, if not stop. The serial method will, in a way, control; as a matter of fact, it hasn't reduced indebtedness thus far. The indebtedness for water supply systems in the small towns of our Commonwealth—and I take it it is only the small towns that this Association is deeply interested in at this time, because the large towns and the cities all have going concerns — actually increased in 1911 over 1910, in 1912 over 1911, and in 1913 over 1912. For those reasons we feel as though the annual payment clause should be retained.

From certain papers which I have read I find that there is a way of financing these extensions. There is no doubt that the health question enters into your water supply systems, and it isn't the purpose of our office in any way to interfere or attempt to interfere with any legitimate health measure; but we do feel that you ought to bring the matter squarely before the people and let them understand that if a burden is to be placed on the town they should bear their portion of it, for posterity most certainly will have troubles of its own.

In financing any plant, admitting it will take somewhere near a year to construct the plant, the statute makes ample provision for financing with a temporary loan, and when the plant is constructed it can be financed then by a permanent loan, and that permanent loan will represent the actual amount that is necessary to construct the plant; whereas if the permanent loan is made in the first instance, you as business men know that you are likely to be over or under, and sometimes when you have funds on hand it is a question where you want to place them. You certainly don't want to put operating costs into thirty-year loans. By financing the first year with a temporary loan, replaced the second year with a permanent loan, you have two years in which to obtain money to meet your first charge on principal. You have to apply on that such sums as will be obtained from premiums, and I don't believe it is necessary to enter into any subterfuge to obtain money from premiums, because the market conditions are such that cer-

tain rates are almost demanded. In fact, to-day, even although you could get a loan on a 3.85 or a 3.79 basis, it would be insisted that the loan should be written on a 4 per cent. basis; so it seems to me that the burden is not so great as to warrant a change in the statute at this time.

I can assure you, gentlemen, from the little experience I have had with legislative committees, that if a new concern gets five years' exemption, every going concern will get five years' exemption. That is certain to follow. Not infrequently you hear it said: "So-and-so got five years, why can't I have it?" But if you have a rule, and constantly live up to it, there is less trouble and less grumbling; and I believe every one should share his portion of the expense. It seems to me that this is no more than we ought to insist upon, in view of the condition of the finances of our cities and towns to-day. The charge on account of interest is simply alarming, and an increase of indebtedness in the last four years of some $15 000 000 in our cities and towns brings before you, gentlemen, something that you want to take into consideration in conjunction with your water supply systems; because the water rates are a tax, the same taxpayer who pays the water rates is the taxpayer who pays the tax, and while the water system is usually looked upon as a self-supporting enterprise, the fact remains, if there is a health measure, and if that is the basis of your argument, why shouldn't you tax the property holder for this health measure, just as you tax him for other health measures?

The burden is not great, and in but few instances can it be shown that it will affect the tax rate more than a dollar on a thousand, and we can show you case after case where the poor town is willing to put $3 or $5 into its tax rate to build roads for the automobilists to ride on and the taxpayer has no use whatever for them himself. I don't believe the burden is great enough to justify a change from the seriously considered limitations, and the increasing ratio has proved that you are going to get almost as unwarrantable a situation as we had under the old statute. It might be equalized, but with the officials with whom we come in contact, — and they are as honest as the day is long, — it would be utterly impossible without expense for legal advice for them legally to issue indebtedness along those lines.

Nothing should be done to prevent a city or town or a district from supplying itself with water, but everything should be done to encourage each district to bear its portion of the burden. If the town is too large to be supplied, organize your district. And it was for that very reason that we were anxious to secure some legislation whereby districts could borrow for exactly the same purposes permitted to cities and towns, as we knew of no statute and no general law under which they could borrow for more than temporary purposes, namely, a one-year loan.

Mr. Hiram A. Miller.* Mr. President, I was very much interested in the bill of 1913, and am now. I think it was a good bill, as towns and cities are too apt to postpone and to leave posterity to pay bills which they should pay themselves. While the amendments which are proposed do not, I think, in general materially affect the general principle of the bill of 1913, I think that the one which postpones the first payment for five years and then requires payment of only one half as much in any year as may be paid in any subsequent year defeats the very object of the bill of 1913. On a thirty-year loan this would permit a municipality to let the loan run for five years without any payment of principal, and then for the next twelve years to pay only one half as much as for the last thirteen years, the result being that the municipality would postpone until the last one third of the time for which the bonds run the payment of over one half of the bonds, and probably at that time the municipality would want an additional extension of the water works and they would not only have to finance that, but to pay off in ten years over one half of the loan which had been made twenty to thirty years previous. For that reason I think that amendment to the existing law is altogether too radical and should not be adopted.

On the question of postponing payments of principal for five years; on account of the small revenue that would be received the first two or three years, and on account of the fact that there would be a good deal of interest to be paid during the construction and before the works were of any great value to the community, — I think the postponement of it for five years, and also the postponement of special improvements in the way of large mains, etc., for

* Consulting Engineer, Boston, Mass.

five years, would be proper enough and wouldn't materially change the general principle of the bill of 1913; but the amendment to prevent a municipality to pay less in any year than in any subsequent year I am very strongly opposed to.

MR. SHERMAN (*by letter*, April 18, 1916). Petition for the legislation suggested in the foregoing paper was duly presented to the legislature and was referred to the Committee on Municipal Finance, which gave a hearing in regular form, at which a number of persons argued in favor of the bill and none in opposition. After considerable further deliberation the committee reported in favor of a portion of the legislation asked for, and the legislature adopted their recommendation in the following Act:

[GENERAL ACTS.]

[CHAP. 62.]

AN ACT RELATIVE TO THE PAYMENT BY CITIES AND TOWNS OF BONDS ISSUED FOR WATER SUPPLY PURPOSES.

Be it enacted, etc., as follows:

SECTION 1. Section fourteen of chapter seven hundred and nineteen of the acts of the year nineteen hundred and thirteen is hereby amended by adding at the end thereof the following: — *provided, however,* that in the case of bonds or notes issued in accordance with clause (2) of section six of this act the first of such annual payments shall be made not later than three years after the date of the bonds or notes issued therefor, — so as to read as follows: — *Section 14.* Cities and towns shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections three, four and nine, by such annual payments as will extinguish the same at maturity, and so that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and so that the amount of such annual payments in any year on account of such debts, so far as issued, shall not be less than the amount of principal payable in any subsequent year, and such annual amount, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished: *provided, however,* that in the case of bonds or notes issued in accordance with clause (2) of section six of this act the first of such annual payments shall be made not later than three years after the date of the bonds or notes issued therefore.

SECTION 2. Section five of chapter eighty-five of the General Acts of the year nineteen hundred and fifteen is hereby amended by adding at the end thereof the following: — *provided, however,* that the first of such annual

payments on account of a loan incurred for the original construction or purchase of a water works system shall be made not later than three years after the date of the bonds or notes issued therefor, — so as to read as follows: — *Section 5.* Districts shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections three and nine of chapter seven hundred and nineteen of the acts of the year nineteen hundred and thirteen, as amended, by such annual payments as will extinguish the same at maturity, and in such manner that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and that the amount of the annual payment in any year on account of any such debt, so far as it may be issued, shall not be less than the amount of principal payable in any subsequent year: and such annual amounts, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished: *provided, however*, that the first of such annual payments on account of a loan incurred for the original construction or purchase of a water works system shall be made not later than three years after the date of the bonds or notes issued therefor.

SECTION 3. This act shall take effect upon its passage. [*Approved March 21, 1916.*]

MUNICIPAL WATER-WORKS FINANCING IN MASSACHUSETTS AS AFFECTED BY RECENT LEGISLATION.

BY CHARLES W. SHERMAN, WILLIAM S. JOHNSON, AND HENRY A. SYMONDS.

It is generally accepted as a self-evident truth that a revenue-producing public-service enterprise, whether or not owned by the municipality, should be self-supporting. The writers feel very strongly that this view is the only correct one, and that anything which renders it difficult or impossible for a water-works system to maintain itself financially is only a trifle less objectionable than taking away the revenue of a water-works system for maintaining streets or other general public uses. Under present laws, however, it is impossible in Massachusetts for a newly established water works to meet its obligations, and it must be supported in considerable measure out of general taxation, thus bringing a heavy burden upon taxpayers who may not be directly benefited by the introduction of water. It is the purpose of the writers to show how present laws affect these conditions and to suggest a remedy.

In former years, the possibility of so arranging the loans for water-works construction that payment of principal might be deferred until the works should have had opportunity to develop a revenue has been in many cases a potent factor in securing the establishment of water-works systems; but the present laws have changed all this and it is no longer possible to make such arrangements of bonds except by virtue of special legislation, which it is very difficult to obtain when opposed to existing general laws.

Until 1913, water-works construction in municipally owned plants in Massachusetts could be financed by bonds running for a period not exceeding thirty years (except as otherwise stipulated in special legislation), due provision being made for retiring such bonds by sinking funds or by serial payments. This was in ac-

cordance with general laws (Revised Laws of Massachusetts, 1902, Chap. 27, Sects. 11, 12, and 13), and there was no distinction between original construction and extensions of works.

Until 1910 there was no provision of law governing the disposal of premiums obtained from the sale of such bonds. At least in some cases, such premiums have been diverted to other municipal purposes, perhaps for maintenance work not in any way related to the purposes for which the bonds were issued. In 1910, on the petition of one of the writers, the legislature passed Chapter 379 of the Acts of that year, providing that in case of sinking fund bonds any premium received should be added to the sinking fund, and the annual contribution correspondingly reduced, and that in the case of serial bonds the premium should be used in retiring the bonds first to mature.

In 1913 the legislature passed an Act, Chapter 719, radically changing the conditions affecting water-works finances. This act provided, in Section 6, that cities and towns may incur debts outside the debt limit, for a period not exceeding thirty years, for the establishment or purchase of a system of water-works, or for the purchase of land for the protection of a water system, or for acquiring water rights; but for the extension of water mains and for water departmental equipment the term of such loans was limited to five years. It was further provided that the proceeds of the sale of any such bonds, with the exception of premiums, should be used only for the purposes specified in the authorization of the loan, except that transfers of unexpended amounts might be made to other accounts to be used for similar purposes. The disposition of premiums, as stipulated by the Act of 1910, remained unchanged. Section 8 provided, among other things, that bonds might be issued "at such rates of interest as may be deemed proper," and that they should be sold at not less than par. Section 13 provided that no further sinking fund bonds should be issued, and Section 14 required that all new bonds be retired by annual payment, the first payment to be made not later than one year after the date of the bonds, and the payment of principal in any year not to be less than the amount payable in any subsequent year.

It will be seen that this act radically changed the conditions

under which money might be borrowed for water-works extensions. While loans for the construction of new works or the purchase of old ones, for acquiring water rights or land for the protection of the water supply, may run for thirty years, all other extensions of water works must be financed on a five-year basis. It will also be noted that in retiring serial bonds, the first payment must be made within one year of the date of the bond, and the payments in the earlier years must be at least as large as, and in many cases larger than, in later years.

These conditions are all of such a nature as to cause hardship in a great many cases, or else, in a large measure, to neutralize the attempts which have been made by people interested in water-works financing to so arrange matters that water works shall be wholly self-supporting.

It is obvious that if water-works constructions are of such a length of life that thirty-year bonds are reasonable in the case of new works or in the purchase of existing works, they would be equally reasonable in the case of extensions. It is well known that very little in the nature of water-works construction has a useful life of less than thirty years, and much of the work has a very much greater life. Thus there is no practical possibility of future generations being called on to pay debt requirements for works which have then disappeared, even in the case of thirty-year loans. Doubtless it is not good financing to borrow money year after year for comparatively small expenses, which are annually recurring, such, for instance, as may be demanded by the annual requirement of installing meters, service-pipe connections, and for ordinary extensions of main pipe to reach new houses, under average conditions. The best financial policy is unquestionably to take care of such requirements out of revenue. On the other hand, special requirements of certain years, such as an unusual reinforcement of the main pipe system, the installation of a new supply, the construction of a new pumping unit or reservoir, may well call for an expenditure in addition to the ordinary annual expenditure for extensions, which it is impracticable to meet out of the revenue of a single year, or, indeed, out of the revenue of five years, without so loading the revenue as to make impossible the payment of fixed charges which, under the provisions of law, would

make necessary the assessment of interest and debt requirements out of taxation.

This condition may be illustrated by the case of the Town of Belmont, where it has been customary for many years to take care of ordinary extensions, as well as interest, sinking-fund and serial-bond requirements, out of water-department revenue. Prior to 1910 the ordinary requirements for construction of mains were about $2 500 annually, and from 1911 to 1914, inclusive, they have ranged from $4 500 to $9 000 annually. In 1913, owing to the very rapid growth of the town, the water works was faced with the necessity of laying a considerable amount of large-sized pipe to reinforce the distribution system. The estimated cost of this improvement was $17 000, in addition to the ordinary requirements for extensions of mains to new houses. It would obviously have been impossible to meet any such sum out of the current revenue. Even under a five-year loan, as required by the present law, the annual requirement for maturing bonds and interest would have ranged from $4 265* in the first year to $3 135* in the fifth year, or nearly as much as the entire sum required for ordinary annual extensions. To meet any such requirement would have necessitated curtailing other necessary expenses or funding them in the form of five-year loans. As a matter of fact, — the law above-referred to not having been enacted at the time this matter came up for discussion, — the bonds were issued for a thirty-year term, with the result that the annual interest and serial-bond requirement was $1 765 the first year and $1 630 the fourth year ($1 000 of bonds maturing annually during this period), and ranged from $1 085 in the fifth year to $522.50 in the thirtieth year, during which period $500 of bonds matured annually. These sums, added to the regular requirements, do not materially increase the burden upon the works.

The folly of borrowing for annually recurring expenditures for ordinary extensions under the five-year loan proposition may be illustrated by the following case: Assumed annual requirement for extension, $8 000, funded in five-year bonds, maturing $1 600 each year; rate of interest, 4 per cent. During the first four years the annual requirement for maturing bonds and interest would in-

* Interest rate, 4½%.

crease from $1 920 to $7 296, and thereafter would remain uniform at $8 960; in other words, after the fifth year there would be spent each year $8 960 to do $8 000 of work, and there would be $24 000 of bonds constantly outstanding. The case is even worse for bonds issued for longer periods; that is to say, borrowing for annually recurring expenses results in material losses.

The only escape from such hardship as would exist in the case of Belmont, quoted above, would seem to be to obtain a special act of the legislature authorizing a longer term for the particular loan under consideration, and such special acts are difficult to obtain.

The provision of law which requires that serial bonds shall be retired by payments, the first of which shall be made not later than one year from the date of the bonds, and which shall not be less than in any succeeding year, is also a hardship, particularly in the case of new works. Assume, for instance, the case of a small town constructing a water-works system costing $60 000. For the construction of the new works its bonds may run for a period of thirty years, but it must begin to pay serial bonds not later than one year from the date of issue, — that is, by the end of one year it must pay at least $2 000 in bonds in addition to the interest on the whole $60 000 for the year. In all probability, nearly a year from the date of borrowing the money will elapse before the works can be completed and put in operation, and the sum to be received in earnings during this time is insignificant. It is, therefore, impossible that the earnings of the water department shall have provided a sum sufficient to pay interest and serial bonds in addition to such operating expenses as may have been incurred during that period. Therefore, under the provisions of law, it will be necessary for the assessors to assess the interest and bond requirements as a part of the tax. During the early years, when none, or at most but a small part, of the bonds have been retired, the interest payments are at their maximum, so that the total demands for interest and maturing bonds are most severe at the time when the works have not developed a revenue and are in the worst condition to meet them. Imagine a private company trying to conduct business on this basis! How long would it continue to exist?

A possible mode of evading this condition exists under the present requirement with regard to premiums. It will be noted that the bonds may be issued at such rates of interest as may be reasonable. At the present time there is a good market for municipal bonds in Massachusetts at 4 per cent., and a slight premium can be obtained. Assuming new works to be started at this time, it might be decided to issue the bonds at $4\frac{1}{4}$ per cent. or $4\frac{1}{2}$ per cent., and such bonds would command a handsome premium, sufficient to take care of the first bonds to mature, — possibly for those maturing within the first two or three years, during which period the works may get upon such a basis that the revenue can care for the debt requirements.

The difficulties of meeting this situation are increased by the provision that the payment of principal shall in no year be less than that of any subsequent year. For instance, assuming a small town building water works to cost $40 000, and issuing bonds for thirty years. If the common practice of issuing bonds in $1 000 pieces is followed, it will be necessary to retire not less than $2 000 of bonds each year during the first ten years; while during the succeeding twenty years the amount to be retired will be but $1 000 every year. The interest requirement (at 4 per cent.) would be $1 600 the first year and but $40 in the thirtieth year, making total charges of $3 600 in the first year, as against $1 040 in the thirtieth year. Thus the load on the water revenue is greatest at the time when the revenue is smallest and least able to meet heavy expenses. The water earnings will certainly be unable to stand the strain, and it will be necessary to call upon general taxation to carry the work during the earlier years. In such a case it is likely that the water rates would be reduced after ten or twenty years, as the fixed charges would then be so small, and the taxpayers would thus be paying during the early years of the works for water used by water consumers in later years; while many of these taxpayers, living in outlying sections, would be benefited only indirectly by the water-works system.

Such conditions as are outlined above obviously discourage the installation of new water works. The taxpayers, at least if the conditions are carefully analyzed in advance, will feel that they are not only asked to lend their credit for water-works bonds,

but that for a number of years during the early history of the works they must advance material sums out of the tax revenue to keep the works going. Under such conditions the construction of water works will be postponed as long as possible.

It will be noted that the Act of 1913 applies only to cities and towns. It was therefore still possible for water districts to issue bonds upon a different basis without contravening existing law, and this was done in a number of cases between 1913 and 1915. It was usually provided in issuing such loans that the first payment of principal should be made five years after the date of the bonds.

Unfortunately, however, a bill was introduced to the legislature of 1915, which extended the restriction to water districts, and as the title of the bill was somewhat blind and as it was referred to the Committee on Municipal Finance and not to the Committee on Water Supply, water-works men in general did not discover that such a proposition was under consideration until it was too late to take any action, and Chapter 85 of the Acts of 1915 had been passed. This chapter, by Section 5, practically extends the provision of the Act of 1913, above referred to, so that in the case of water districts, as in the case of cities and towns, the first payment of serial loans must be made not later than one year from the date of the issue of the bond.

It is believed that the bills to which we have herein taken objection were introduced into the legislature, and enacted by it, with the best of intentions, but without realizing what their effect must necessarily be. We believe, however, that the examples cited above, and numberless others which might be quoted, show that, whatever benefits may have resulted from these acts, — and it is not clear to us that there have been any benefits, — they have been obtained at the expense of other more desirable conditions. The undesirability of special legislation, except in cases of real necessity, is generally recognized. Yet the existing laws practically force every water-works system to apply for special legislation in the case of any unusual expenditure. The advantage of a municipal public-service enterprise being self-supporting is also admitted, but the present laws make it difficult, and in some cases impossible, for this result to be attained. The desirability

of the introduction of a public supply of water in municipalities of any considerable size is unquestionable, and most of us believe that, where there is sufficient public spirit in a community, it is wiser that such works be built by the municipality rather than by a private company. The existing laws, however, throw such difficulties in the way of successfully starting such an enterprise as to practically prohibit further construction in this way by the public. The effect must necessarily be the original construction of such works by private companies. If municipal ownership is desired, it will be necessary that the municipality wait until the private enterprise is on a paying basis, when it may be expected that the income from the established business will be sufficient to carry the necessary investment.

The writers of this paper have petitioned the present legislature for an amendment to the existing laws, which will, it is believed, correct the conditions outlined in this paper. The present laws, and their form if amended as suggested, are as follows:

Existing Laws.	Changes Suggested by Proposed Amendments.
Chapter 719, Acts of 1913.	
Sect. 6. Cities and towns may incur debt, outside the limit of indebtedness prescribed in this act, for the following purposes and payable within the periods hereinafter specified:	
(1) For temporary loans under the provisions of sections three, four or nine, one year.	(Unchanged.)
(2) For establishing or purchasing a system for supplying the inhabitants of a city or town with water, or for the purchase of land for the protection of a water system, or for acquiring water rights, thirty years.	(Unchanged.)
(3) For the extension of water mains and for water departmental equipment, five years.	(3) For the extension of water mains and for the construction of reservoirs, standpipes, pumping stations, and pumping equipment, twenty years.

Existing Laws.	Changes Suggested by Proposed Amendments.
	(4) For the purchase and installation of water meters and for other water departmental equipment not included in Clause 3, ten years.
(4)* For establishing, purchasing, extending or enlarging a gas or electric lighting plant within the limits of the territory within which such gas or electric lighting plant is authorized to distribute its product, twenty years; but the indebtedness so incurred shall be limited to an amount not exceeding in a town five per cent. and in a city two and one-half per cent. of the last preceding assessed valuation of such town or city.	(Clause 5 will be old Clause 4 unchanged but renumbered.)
Sect. 14. Cities and towns shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections three, four and nine, by such annual payments as will extinguish the same at maturity, and so that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and so that the amount of such annual payments in any year on account of such debts so far as issued shall not be less than the amount of principal payable in any subsequent year, and such annual amount, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished.	(Unchanged.)
	Add, — provided, however, that in the case of bonds issued in accordance with Clause 2 of Section 6 of this Act, the first of such annual

* As amended by Chapter 115, Acts of 1915.

Existing Laws.	Changes Suggested by Proposed Amendments.
	payments shall be made not later than five years after the date of the bonds or notes issued therefor, and the amount of annual payment in any year on account of such bonds shall not be less than one half the amount of principal payable in any subsequent year.
Chapter 85, Acts of 1915.	(Unchanged.)
SECT. 5. Districts shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections 3 and 9 of chapter seven hundred and nineteen of the acts of the year nineteen hundred and thirteen, as amended, by such annual payments as will extinguish the same at maturity, and in such manner that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and that the amount of the annual payment in any year on account of any such debt, so far as it may be issued, shall not be less than the amount of principal payable in any subsequent year; and such annual amounts, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished.	Add, — provided, however, that the first of such annual payments on account of a loan incurred for the original construction or purchase of a water-works system shall be made not later than five years after the date of the bonds or notes issued therefor, and that the amount of the annual payment in any year, on account of any such debts for the original construction or purchase of such water-works system, so far as it may be issued, shall not be less than one half the amount of the principal payable in any subsequent year.

PROCEEDINGS.

HOTEL BRUNSWICK,
BOSTON, MASS., March 8, 1916.

William F. Sullivan, President, in the chair.
The following-named members and guests were present:

HONORARY MEMBERS.

E. C. Brooks, R. C. P. Coggeshall, Albert S. Glover, Frank E. Hall. — 4.

MEMBERS.

S. A. Agnew, C. L. Baker, L. M. Bancroft, F. A. Barbour, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, G. A. Carpenter, J. C. Chase, H. S. Clark, H. W. Clark, John Cullen, J. M. Diven, E. D. Eldredge, G. F. Evans, F. F. Forbes, Patrick Gear, H. T. Gidley, F. J. Gifford, H. J. Goodale, J. W. Graham, R. K. Hale, A. R. Hathaway, D. A. Heffernan, W. F. Howland, J. L. Howard, A. C. Howes, J. A. Hoy, E. F. Hughes, G. A. Johnson, W. S. Johnson, E. W. Kent, Willard Kent, Patrick Kiernan, G. A. King, Horace Kingman, Morris Knowles, E. J. Looney, P. J. Looney, F. A. McInnes, S. H. McKenzie, Thomas McKenzie, W. A. McKenzie, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, H. A. Miller, J. W. O'Neill, F. L. Northrop, H. N. Parker, Dwight Porter, T. A. Pierce, H. E. Perry, H. G. Pillsbury, G. A. Sampson, C. M. Saville, A. L. Sawyer, C. W. Sherman, H. H. Sinclair, Sidney Smith, G. H. Snell, G. A. Stacy, W. F. Sullivan, E. J. Titcomb, D. N. Tower, C. H. Tuttle, W. H. Vaughn, Ernest Wadsworth, R. S. Weston, W. J. Wetherbee, L. J. Wilber, F. B. Wilkins, F. I. Winslow, G. E. Winslow, I. S. Wood. — 77.

ASSOCIATES.

Builders Iron Foundry, A. B. Coulters; A. M. Byers Co., H. F. Fiske; Central Foundry Co., W. Todd and W. H. Feltt; Chapman Valve Mfg. Co., C. E. Pratt and J. T. Mulgrew; Darling Pump and Mfg. Co., H. A. Snyder; Eddy Valve Co., H. W. Dotten; F. H. Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., Albert S. Glover, J. H. Smith, and W. A. Hersey; Lead-Lined Iron Pipe Co., T. E. Dwyer; Ludlow Valve Mfg. Co., G. A. Miller; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., H. J. C. Lufkin; National Water Main Cleaning Co., B. B. Hodgman; Neptune Meter Co., H. H. Kinsey and R. D. Wertz; Pittsburgh Meter Co., J. W. Turner; Rensselaer Valve Co., C. L. Brown; Ross Valve Mfg. Co., William Ross; A. P. Smith Mfg. Co., F. L. Northrop; Thompson Meter Co., E. M. Shedd; Union

Water Meter Co., F. E. Hall and Edward Otis; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, Samuel Harrison and W. F. Bird. — 30.

GUESTS.

Richard Comerford and P. M. Thea, Worcester, Mass.; Neil Collins, Cambridge, Mass.; James Kinlock, East Greenwich, R. I.; W. B. Gerrish, Springfield, Mass.; Geo. E. Hildreth, Manchester, Mass.; Robert Beverage, Attleboro, Mass.; Leroy Peterson, Duxbury, Mass. — 8.

The Secretary presented applications for membership, duly recommended and endorsed, from J. W. O'Neill, Montreal, Canada, engaged with the water works, Montreal, for the past nineteen years, now chief of meter and inspection departments; Samuel Dyer, Attleboro, Mass., city engineer; Samuel M. Gray, Providence, R. I., engaged in the designing, construction, and maintenance of water works and sewers, and railroad work, in various parts of the country, for many years; W. B. Everett, Montesano, Wash., manager Northwest Electric & Water Works, Montesano, Wash.; George W. Simons, Jr., 1075 Boylston St., Boston, Mass., assistant, civil engineering department, Massachusetts Institute of Technology; E. L. Strauss, Cleveland, Ohio, president of the Central Brass Manufacturing Company (for associate membership).

On motion, the Secretary was directed to cast one ballot in favor of the admission of the applicants, and he having done so they were declared duly elected members of the Association.

The President called on Mr. Charles W. Sherman to give a brief résumé of the report of Committee on Meter Rates. Mr. Richard K. Hale read a discussion which Mr. Allen Hazen sent him from San Francisco, also a letter from Mr. A. E. Walden, of the Baltimore County Water and Electric Company. The President called on Mr. Caleb M. Saville, who read a discussion and made the following motion: That the final action on the report of the Committee on Meter Rates be postponed until the first fall meeting, and that the committee be requested to submit other methods of rate schedule that were considered by them.

The discussion on the report and also on Mr. Saville's motion was participated in by Messrs. McLean, Macksey, Coggeshall,

Diven, Brooks, McKenzie, Gear, William S. Johnson, Barbour, and Gill. The President then put the motion, and declared it unanimously adopted and the matter recommitted to the committee.

Mr. Robert Spurr Weston, Boston, read a paper on "The Proposed Auxiliary Water Supply for the City of Brockton." The paper was discussed by Mr. George A. Johnson.

The last business on the program for the afternoon was entitled "Preliminary Report of Committee on Service Pipe." The President called on Mr. William S. Johnson, the chairman of the committee, who summarized the report. The President, Mr. A. E. Martin, and Mr. Coggeshall made brief remarks; and on the President's suggestion that the matter be postponed until the annual meeting, thereby hoping to get a broader discussion, Mr. Horatio N. Parker made a motion to that effect. The motion was seconded and unanimously adopted.

JUNE MEETING.

PEMBERTON INN,
PEMBERTON, MASS., June 21, 1916.

The June meeting of the New England Water Works Association was held at Pemberton Inn., Pemberton, Mass., June 21, 1916, in conjunction with the Boston Society of Civil Engineers.

The following members and guests were present:

HONORARY MEMBERS.

Edwin C. Brooks, R. C. P. Coggeshall, Albert S. Glover, Frank E. Hall, George A. Stacy. — 5.

MEMBERS.

D. L. Agnew, S. A. Agnew, C. L. Baker, L. M. Bancroft, F. A. Barbour, J. F. Barrett, C. H. Bartlett, J. W. Blackmer, E. M. Blake, G. A. Carpenter, P. M. Churchill, S. K. Clapp, F. L. Cole, C. W. Ellis, Jr., C. H. Eglee, Frank Emerson, James Fitzgerald, F. L. Fuller, H. F. Frost, Patrick Gear, F. J. Gifford, J. A. Gould, R. A. Hale, J. O. Hall, D. A. Heffernan, C. R. Hildred, J. L. Howard, E. F. Hughes, C. E. Johnson, W. H. Jaques, W. S. Johnson, Willard Kent, G. A. King, C. F. Knowlton, Godfrey Knight, W. F. Learned, F. A. McInnes, J. N. McKernan, Hugh McLean, A. D. Marble, A. E. Martin,

W. E. Maybury, John Mayo, F. E. Merrill, G. F. Merrill, J. H. Perkins, H. G. Pillsbury, W. H. Pitman, J. H. Remick, A. L. Sawyer, G. G. Shedd, J. E. Sheldon, Sidney Smith, G. H. Snell, J. T. Stevens, W. M. Stone, W. F. Sullivan, H. A. Symonds, S. E. Tinkham, D. N. Tower, L. R. Washburn, W. J. Wetherbee, F. H. White, F. B. Wilkins, G. E. Winslow, D. M. Wood, I. S. Wood. — 67.

ASSOCIATES.

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GUESTS.

Maine: South Harpswell, Rear Admiral (retired) R. E. Peary. New Hampshire: Little Boar's Head, Mrs. W. H. Jaques. Massachusetts: Allston, E. G. Kinsey; Andover, Mrs. F. L. Cole; Arlington, Mrs. E. M. Shedd; Belmont, Mrs. Dana M. Wood, Master J. Elliott Wood; Beverly, Mr. and Mrs. Thomas A. Appleton, Arthur B. Appleton, H. G. Porter; Brookline, Mrs. C. H. Eglee; Boston, Mrs. Frank M. Bates, Herbert W. Dyer, Miss Mary E. Evans, Mr. A. Friend, Charles F. Glavin, Miss M. E. Hallinan, Miss Joan M. Ham, C. E. Kelley, Mrs. A. M. Lovis, Mrs. J. Herman Smith, Master Ellsworth Smith, Mrs. S. E. Tinkham, F. P. Wilcox; Braintree, William C. Harrison, John Kelley, Mrs. W. E. Maybury, Louis W. Thayer; Bridgewater, Miss Beulah Hopkins, Mrs. John Mayo; Cambridge, Eugene F. Sullivan; Dedham, Mrs. Frank J. Gifford; Everett, Arthur L. Gammage; Florence, Mrs. F. M. Sears; Holyoke, Helen A. Hanley, Mrs. Hugh McLean, Marion McLean, Katharine G. Sullivan; Leominster, Mrs. W. J. Wetherbee; Malden, Mrs. Harold L. Bond, Mrs. William F. Woodburn; Melrose, Mrs. E. C. Brooks, Mrs. C. F. Knowlton, C. F. Knowlton, Jr., Mrs. A. M. Lovis; Mattapoisett, Manuel R. Kousahe; New Bedford, William A. Tucker; Newton, Alfred E. Burton, Thomas C. Davis, Ernest L. Foley; Norwood, Lyman W. Bigelow; North Andover, Frank E. Smith; Peabody, Edward A. Blaney, Joseph A. Ryan; Reading, Mrs. L. M. Bancroft; Randolph, Mr. and Mrs. John F. Thomas; Roxbury, George C. Ambrose; Shrewsbury, Romeo E. Allen; Somerville, Mrs. C. H. Bartlett, Helen G. Blake, Mrs. Samuel Harrison, Mrs.

C. R. Hildred; Waban, Mrs. H. A. Symonds; Waltham, A. W. Parker, Frank L. Preble, Mrs. G. E. Winslow; Watertown, John M. Cashman, Miss Mabel A. Perkins; Wellesley Hills, Mrs. F. L. Fuller, Miss Pearl M. Jones, Harriet C. Sammons; West Roxbury, Mr. and Mrs. C. H. Dodd, D. S. Reynolds. Rhode Island: Pawtucket, Mrs. G. A. Carpenter, Miss E. R. Whitaker; Providence, Horace T. Almy, M. A. Shaw, Mrs. I. S. Wood; Narragansett Pier, Mrs. Willard Kent. New York: Troy, Mrs. F. S. Bates. — 83.

The joint Field Day of the two organizations proved very enjoyable, and the program of ball game, dinner at Pemberton Inn, with musical and literary exercises, business meetings of Association and Society, was fully carried out, with an attendance of 193. Rear-Admiral Peary, U. S. N., Retired, was present as a guest, and favored the assemblage with a forceful and interesting address on the current topic of the hour, Preparedness.

At the business meeting of the New England Water Works Association, President William F. Sullivan presiding, seventy applications for active and one for associate membership were presented, viz., —

Frederic L. Andrews, Sanford, Me., superintendent; Frederick W. Bateman, Clinton, Mass., civil engineer; G. A. Bean, Derry, N. H., superintendent; George W. Bowers, Cleveland, Ohio, civil engineer; George F. Bourne, Lenox, Mass., water commissioner; Homer E. Bridge, Hazardville, Conn., manager and superintendent; James L. Bryne, Boston, Mass., construction engineer; John Byrne, Westbrook, Me., superintendent; B. R. Chapman, Brockton, Mass., city engineer; Guy H. Chase, Fitchburg, Mass., commissioner of streets and engineering; Joseph S. Craigue, Walpole, Mass., civil engineer; Charles W. Eddy, Thomaston, Conn., civil engineer; Charles W. Ellis, Jr., Mattapoisett, Mass., superintendent; Frank Emerson, Peabody, Mass., superintendent; Henry F. Frost, South Easton, Mass., treasurer; H. L. Foster, Boston, Mass., civil engineer; W. A. Gardner, Suffield, Conn., superintendent; Marshall R. Goding, Portland, Me., auditor; Pearl T. Gray, Portland, Me., registrar; J. Francis Granger, Marlboro, Mass., engineer; Jacob A. Handy, South Dartmouth, Mass., chairman water commissioners; George B. Hamblin, Whitinsville, Mass., purchasing agent; John V. Hazen, Hanover, N. H., instructor of engineering, Dartmouth College; Charles R. Hildred, Somerville, Mass., chief clerk, office of water department; Charles I. Hosmer, Turners Falls, Mass., hydraulic engineer; William L. Howard, Hingham, Mass.; William H. Jaques, Little Boar's Head, N. H., president Hampton Water

Works Company; Minol S. Kaharl, West Somerville, Mass., clerk, Wiscasset Water Company; J. Frank Kidder, Burlington, Vt., superintendent; Godfrey Knight, Avon, Mass., superintendent; Beardsley Lawrence, Dorchester, Mass., civil engineer; Joseph F. A. Leonard, Fall River, Mass., civil engineer; Sheldon E. Minor, Greenwich, Conn., civil engineer; Morton L. Miller, Springfield, Mass., master mechanic, water works; Oren M. Moulton, Gorham, Me., consulting engineer; Hugh Nawn, Roxbury, Mass., civil engineer; Reeves J. Newsom, Lynn, Mass., superintendent; John E. Palmer, Boston, Mass., consulting engineer; John Parsons, Somersworth, N. H., superintendent; Stanley G. Proverbs, New Bedford, Mass., hydraulic engineer; Edwin L. Pride, Boston, Mass., accountant; Joseph B. Sando, Boston, Mass., mechanical engineer; Harry W. Sawyer, Manchester, N. H., civil engineer; Walter H. Sawyer, Lewiston, Me., hydraulic engineer; Warren J. Simonds, Marlboro, Mass., city engineer; George G. Shedd, Manchester, N. H., consulting engineer; A. H. Starkweather, Wakefield, Mass., superintendent; Ralph Sweetland, Boston, Mass., engineer, Insurance Exchange; Frederic H. Taber, New Bedford, Mass., member water board; Alfred H. Terry, Bridgeport, Conn., city engineer; Alberti T. Thompson, Rockville, Conn., superintendent; Frank M. Travis, Torrington, Conn., superintendent; C. L. Ward, Portland, Me., superintendent meter department; North M. West, Kennebunk, Me., manager York Water Company; William Jay Willson, Greenwich, Conn., superintendent; F. R. Woodward, Hill, N. H., manager and owner water works; Edward Wright, Boston, Mass., civil engineer.

Non-resident: Roger W. Armstrong, New York, N. Y., engineer Board of Water Supply; A. C. Bingham, Marysville, Calif., manager water company; W. P. Brereton, Winnipeg, Manitoba, city engineer; D. A. Decrow, Buffalo, N. Y., mechanical engineer; William Flannery, Brooklyn, N. Y., mechanical engineer; Charles A. Furley, Pittsburgh, Pa., superintendent; Edgar B. Kay, Tuscaloosa, Ala., consulting engineer; Carlos Lobo, Brooklyn, N. Y., superintendent in charge of maintenance operation, extension and improvement of water supply system; John T. Metcalf, Brooklyn, N. Y., civil engineer; Armory G. Singletary, San José, Calif., director, Water Company; C. L. Scofield, Montreal, Canada, manager, Canadian Fire Underwriters Association; Linden C. Trow, Lake Forest, Ill., superintendent; J. A. Vertefeuille, Richmond Hill, N. Y., assistant engineer, Brooklyn Water Department. (70.)

Associate: The Smith & Abbott Company, Portland, Me. (1.)

They were by unanimous vote duly elected thereto.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, March 8, 1916.

Present: President William F. Sullivan and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, R. C. P. Coggeshall, F. J. Gifford, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

Five applications for active membership and one for associate were received and they were by unanimous vote recommended therefor.

W. B. Everett, manager Northwest Electric and Water Works, Montesano, Wash.; George W. Simons, Jr., assistant, Civil Engineering Department, Massachusetts Institute of Technology, 1075 Boylston St., Boston, Mass.; J. W. O'Neill, chief of Meter and Inspection Departments, City Hall, Montreal, Canada; Samuel M. Gray, designing, construction, and maintenance of water works and sewers and railroad work, Providence, R. I.; Samuel Dyer, civil engineer, Water and Sewer Department, city engineer, Attleboro, Mass. Associate: Central Brass Manufacturing Company, Cleveland, Ohio.

The place of holding the next Annual Convention was discussed without definite action.

The President appointed Messrs. Charles W. Sherman, Richard K. Hale, Samuel E. Killam, William E. Maybury, and F. J. Gifford a Committee of Arrangements for the June outing of the Association.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, March 29, 1916.

Present: President William F. Sullivan, members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, R. C. P. Coggeshall, R. J. Thomas, F. J. Gifford, R. K. Hale, L. M. Bancroft, G. A. King, Willard Kent, and William S. Johnson, Leonard Withington, and Frank A. McInnes.

Mr. Leonard Withington, of Portland, Me., presented the advantages of that city as a place for holding the next Annual Convention, and, after discussion, on motion of Mr. Thomas, seconded by Mr. Coggeshall, it was unanimously voted, that the Annual Convention of the New England Water Works Association for 1916 be held at Portland, Me., September 13, 14, and 15.

On motion of Mr. Coggeshall, seconded by Mr. Thomas, it was unanimously voted, that the salary of Miss Ham, Assistant Secretary, be made eight hundred dollars for the current year, increase to date from January 1, 1916.

A report of progress was made by Messrs. Coggeshall and Johnson, of the Membership Committee.

On motion of Mr. King, it was voted, that the President and Secretary be a committee to investigate and report at the June meeting on the advisability of holding an October meeting in the western section of New England.

The President was authorized to appoint a committee of arrangements for the Annual Convention, said committee to have full powers.

The freedom of headquarters of this Association was granted members of the Vermont Society of Civil Engineers, the Boston Society of Civil Engineers having already taken similar action.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association on steamer *Miles Standish*, Boston Harbor, June 21, 1916.

Present, William F. Sullivan, President, and members D. A. Heffernan, R. C. P. Coggeshall, F. J. Gifford, L. M. Bancroft, G. A. King, and Willard Kent.

Seventy-one applications were received, seventy for active and one for associate membership, as follows:

Frederic L. Andrews, Sanford, Me., superintendent; Frederick W. Bateman, Clinton, Mass., civil engineer; G. A. Bean, Derry, N. H., superintendent; George W. Bowers, Cleveland, Ohio, civil engineer; George F. Bourne, Lenox, Mass., water commissioner; Homer E. Bridge, Hazardville, Conn., manager and superintendent; James L. Bryne, Boston, Mass., construction engineer; John Byrne, Westbrook, Me., superintendent; B. R. Chapman, Brockton, Mass., city engineer; Guy H. Chase, Fitchburg, Mass., commissioner of streets and engineering; Joseph S. Craigue, Walpole, Mass., civil engineer; Charles W. Eddy, Thomaston, Conn., civil engineer; Charles W. Ellis, Jr., Mattapoisett, Mass., superintendent; Frank Emerson, Peabody, Mass., superintendent; Henry F. Frost, South Easton, Mass., treasurer; H. L. Foster, Boston, Mass., civil engineer; W. A. Gardner, Suffield, Conn., superintendent; Marshall R. Goding, Portland, Me., auditor; Pearl T. Gray, Portland, Me., registrar; J. Francis Granger, Marlboro, Mass., engineer; Jacob A. Handy, South Dartmouth, Mass., chairman water commissioners; George B. Hamblin, Whitinsville, Mass., purchasing agent; John V. Hazen, Hanover, N. H., instructor of engineering, Dartmouth College; Charles R. Hildred, Somerville, Mass., chief clerk, office of water department; Charles I. Hosmer, Turners Falls, Mass., hydraulic engineer; William L. Howard, Hingham, Mass.; William H. Jaques, Little Boar's Head, N. H., President Hampton Water Works Company; Minol S. Kaharl, West Somerville, Mass., clerk, Wiscasset Water Company; J. Frank Kidder, Burlington, Vt., superintendent; Godfrey Knight, Avon, Mass., superintendent; Beardsley Lawrence, Dorchester, Mass., civil engineer; Joseph F. A. Leonard, Fall River, Mass., civil engineer; Sheldon E. Minor, Greenwich, Conn., civil engineer; Morton L. Miller, Springfield, Mass., master mechanic, water works; Oren M. Moulton, Gorham, Me., consulting engineer; Hugh Nawn, Roxbury, Mass., civil engineer; Reeves J. Newsom, Lynn, Mass., superintendent; John E. Palmer, Boston, Mass., consulting engineer; John Parsons, Somersworth, N. H., superintendent; Stanley G. Proverbs, New Bedford, Mass., hydraulic engineer; Edwin L. Pride, Boston, Mass., accountant; Joseph B. Sando, Boston, Mass., mechanical engineer; Harry W. Sawyer, Manchester, N. H., civil engineer; Walter H. Sawyer, Lewiston, Me., hydraulic engineer; Warren J. Simonds, Marlboro, Mass., city engineer; George G. Shedd, Manchester, N. H., consulting engineer; A. H. Starkweather, Wakefield, Mass., superintendent; Ralph Sweetland, Boston, Mass., engineer, Insurance Exchange; Frederic H.

Taber, New Bedford, Mass., member water board; Alfred H. Terry, Bridgeport, Conn., city engineer; Alberti T. Thompson, Rockville, Conn., superintendent; Frank M. Travis, Torrington, Conn., superintendent; C. L. Ward, Portland, Me., superintendent meter department; North M. West, Kennebunk, Me., manager York Water Company; William Jay Willson, Greenwich, Conn., superintendent; F. R. Woodward, Hill, N. H., manager and owner water works; Edward Wright, Boston, Mass., civil engineer.

Non-resident: Roger W. Armstrong, New York, N. Y., engineer Board of Water Supply; A. C. Bingham, Marysville, Calif., manager water company; W. P. Brereton, Winnipeg, Manitoba, city engineer; D. A. Decrow, Buffalo, N. Y., mechanical engineer; William Flannery, Brooklyn, N. Y., mechanical engineer; Charles A. Furley, Pittsburgh, Pa., superintendent; Edgar B. Kay, Tuscaloosa, Ala., consulting engineer; Carlos Lobo, Brooklyn, N. Y., superintendent in charge of maintenance operation, extension and improvement of water supply system; John T. Metcalf, Brooklyn, N. Y., civil engineer; Armory G. Singletary, San José, Calif., director, Water Company; C. L. Scofield, Montreal, Canada, manager, Canadian Fire Underwriters Association; Linden C. Trow, Lake Forest, Ill., superintendent; J. A. Vertefeuille, Richmond Hill, N. Y., assistant engineer, Brooklyn Water Department. (70.)

Associate: The Smith & Abbott Company, Portland, Me. (1.)

They were by unanimous vote recommended therefor.

The committee appointed to consider the advisability of holding a meeting of the Association in October at some place in the western portion of New England reported the result of their investigation without recommendation, and the subject was referred to the September meeting of the Executive Committee.

The advisability of the appointment of a committee to consider the subject of Rates for Fire Protection, and to report thereon, was discussed, and it was voted that the matter be brought to the attention of the Association.

Voted, That the President be authorized to appoint a committee on Form of Statistics of Assets, should he deem it desirable.

Adjourned.

WILLARD KENT, *Secretary.*

715 TREMONT TEMPLE, BOSTON, MASS., April 7, 1916.

A meeting of the Committee of Arrangements for the 1916 Annual Convention of our Association was held at headquarters, Boston, on Friday, April 7, 1916.

The meeting was called to order at 11 o'clock A.M., Chairman William S. Johnson presiding. There were present, President Sullivan, of Nashua, N. H.; James Burnie, of Biddeford, Me.; and Secretary Kent; William F. Woodburn was also present, bearing a letter of authorization from Mr. James W. Graham, of Portland, Me., who was unable to be present, and acted as his substitute.

Mr. Johnson read a letter from Mr. W. S. Garde, of Hartford, Conn., regretting that business of the City of Hartford called him to Washington, D. C., and thereby prevented his meeting with the committee. Messrs. Charles W. Sherman and Frank A. Barbour were also present and acted with the committee at the request of Chairman Johnson.

The organization of the committee was completed by the election of Mr. Graham as secretary and Mr. Vernon F. West as treasurer. Mr. Willard Kent was elected secretary pro tem. of the committee.

A general discussion of hotel accommodations, entertainment, financial matters, etc., was held, after which the following named action was taken:

Voted, That Messrs. James W. Graham and Vernon F. West be and are hereby appointed a committee on finance.

Voted, That Messrs. William S. Johnson, Frank A. Barbour, and Charles W. Sherman be and are hereby appointed a committee to secure papers for presentation at the convention.

Voted, That Messrs. James W. Graham, James Burnie, and Vernon F. West be and are hereby appointed a committee on entertainment for the convention.

Voted, That Mr. William S. Johnson, chairman, be empowered to make any further arrangements necessary, in his judgment, for the success of the convention.

Adjourned, subject to the call of the chair.

WILLARD KENT, *Secretary pro tem.*

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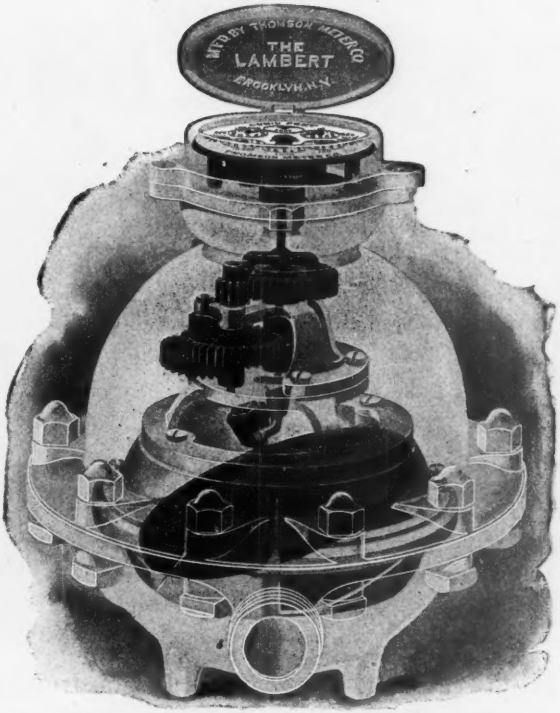

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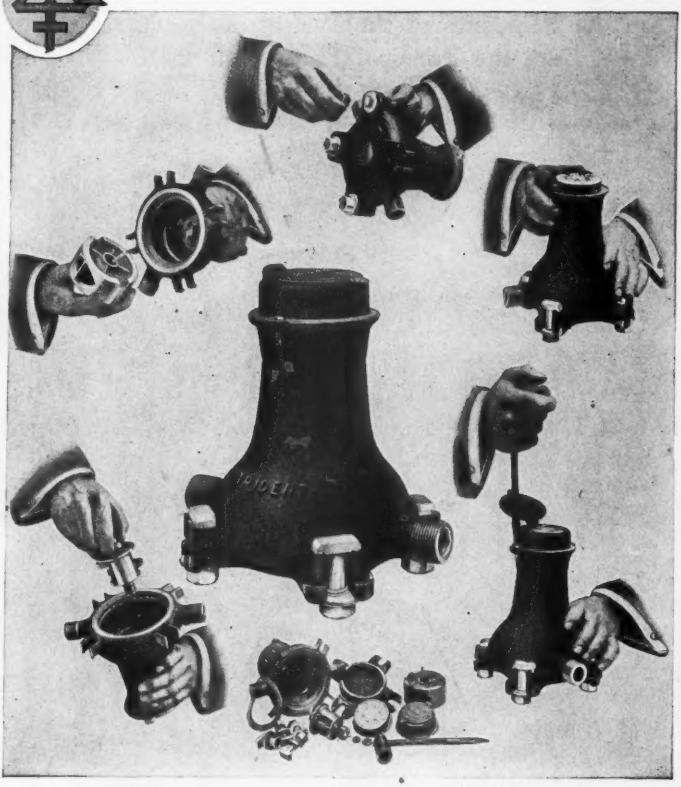

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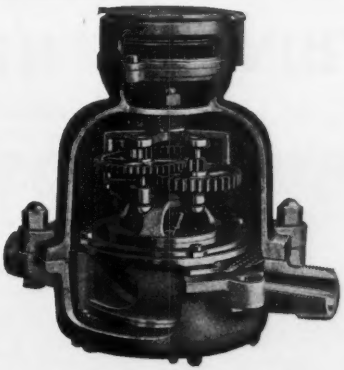

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Water Meters

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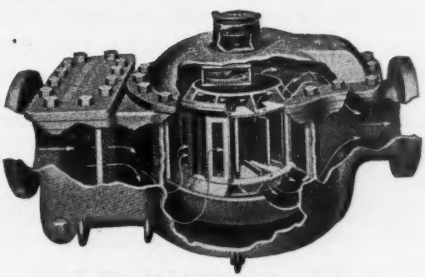

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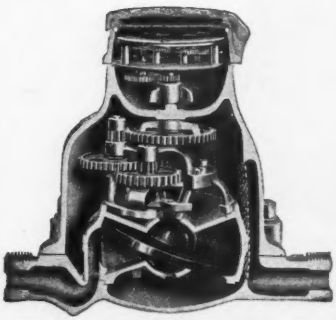
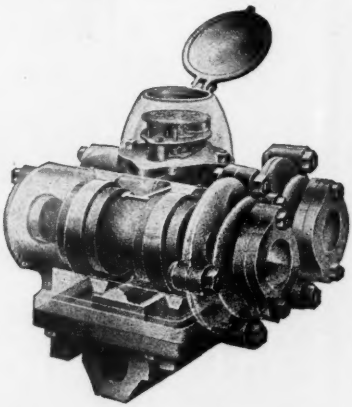
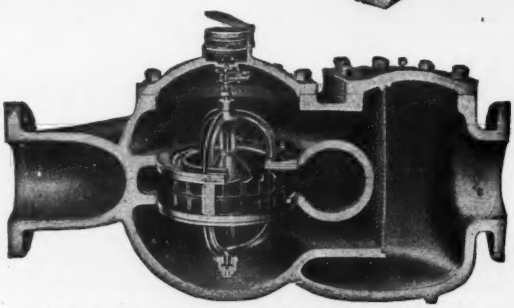
WORTHINGTON METERS

The Worthington Duplex Piston Meter is particularly adapted to large and heavy water works services.





The Worthington Disc Meter combines minimum weight with reliability on constant service and accuracy of registration.



The Worthington Turbine Meter
is designed primarily to handle large volumes of water with minimum loss of pressure.

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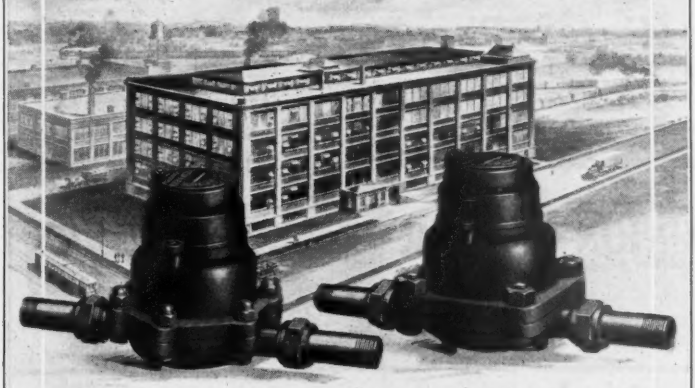
AMERICAN AND NIAGARA
WATER METERS



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have sold our meters for twenty-four years — each meter, by its performance, selling others in an endless chain. No stronger evidence of a good meter should be required, yet the meters we manufacture to-day are a great improvement upon the meters of years ago, and will give even greater satisfaction

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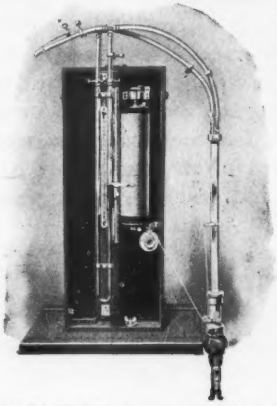

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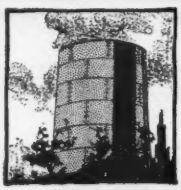

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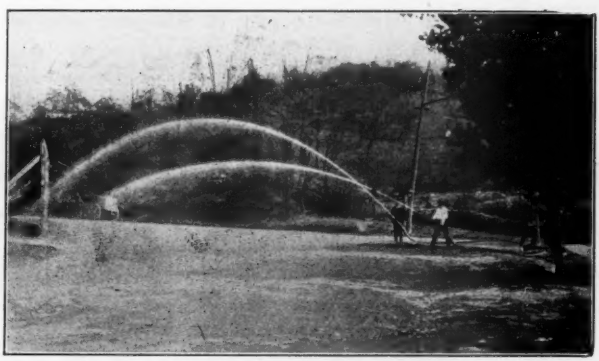

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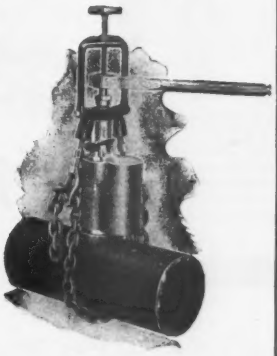

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Few Working Parts
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We can prove these facts by sending a machine to you on thirty days' trial.

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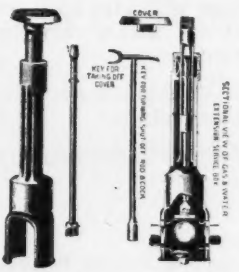

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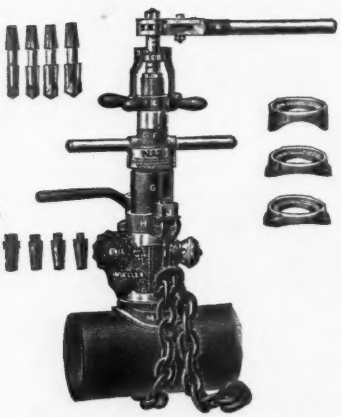

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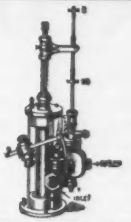

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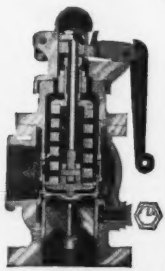

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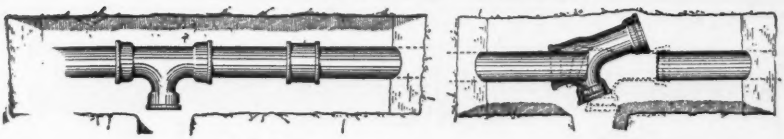

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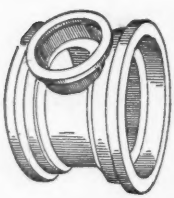

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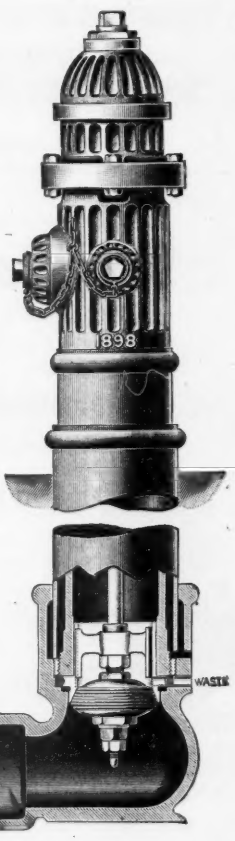

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A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.

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DOUBLE DISK
ANTI-FRICTION
EXTRA WEIGHT, FINISH
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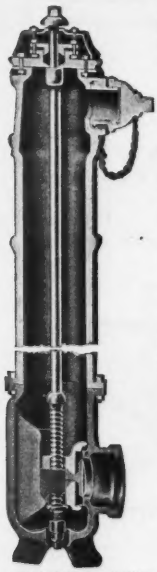

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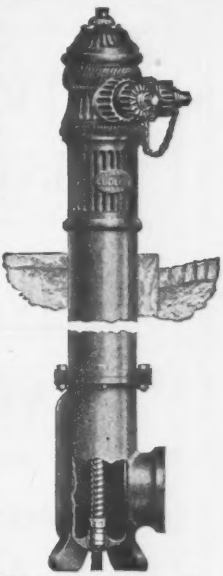
The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



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THE CHAPMAN VALVE MANUFACTURING COMPANY

Manufacturers of

Gate Valves Drip Valves

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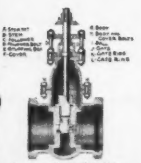
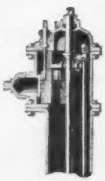
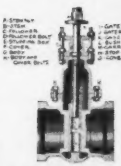


Section of Taper Seat-Valve.



Hydrant with Independent Nozzle Cut-off.



Section of Parallel Seat-Valve.

Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

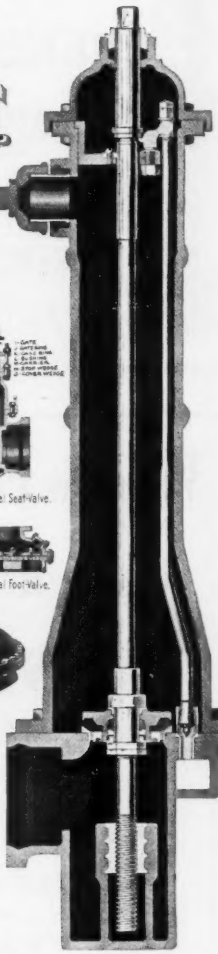
Horizontal Check-Valve.

Vertical Foot-Valve.

Hydrant with Water Crane Attachment.

Indicator Post.

Water Crane with Automatic Drip Valve.



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Total Daily Capacity 900,000,000 Gallons

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FOR WATER, GAS, SEWERS, DRAINS, ETC.

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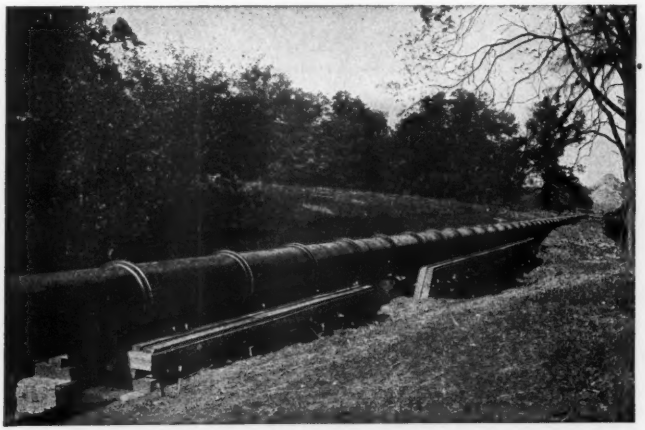

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The copies of the September, 1914, Journal have been entirely disposed of. Members who are willing to dispose of their copies will kindly mail them to the Secretary who will pay 75 cents a copy for a limited number. The following Journals are also wanted to make up sets: June, September and December, 1887; September, 1888; June, 1893; March and September, 1899; and September, 1905.

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